ULTRA-WIDEBAND ANTENNA DESIGN FOR THE USQ-146 INSTALLATION ON THE H-60 HELICOPTER

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The current configuration of the USQ-146 radio system on the H-60 helicopter uses two vertically-polarized transmit antennas and one vertically-polarized receive antenna. The purpose of this design is to replace the two existing transmit antennas with one vertically-polarized ultra-wideband omni-directional antenna for use on an H-60 equipped with a USQ-146 radio system. The antenna should have a VSWR less than three, ideally less than two, over the frequency range of 30-500 MHz. The antenna has to mount through an existing cargo hole and retract or fold for ten-inch ground clearance beneath the helicopter when landed. The H-60 3-D solid model was created with the MicroScribe-3DX digitizer, Rhinocerous NURBS modeling software V1.1 and Ansoft's High Frequency Structure Simulator (HFSS) Solid Modeler. The antenna was designed and its performance predicted using HFSS. HFSS is based on the finite element method and generates accurate results for realistic antennas. Three sizes of nine configurations of flat blade antennas were analyzed with HFSS. The successful design was an 88 cm tall bell-shaped flat blade antenna with a capacitive load on the end.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Information Warfare, Jamming, Antennas

ENGINEERING A WIRELESS DIGITAL NETWORK OPERATIONS CAPABILITY

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The abstract for this thesis is classified FOR OFFICIAL USE ONLY.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Wireless Local Area Network, WLAN, IEEE 802.11b, Digital Network Operations, DNO

BLUETOOTH TECHNOLOGY AND ITS IMPLEMENTATION IN SENSING DEVICES

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Bluetooth Wireless technology is the world's new short range RF transmission standard for small form factor, low cost, and short-range radio link between portable and desktop devices. This technology does not replace Wireless LANs rather it compliments them. Bluetooth wireless technology has many advantages over other Wireless LAN technologies, which makes it attractive to many applications. One such application is in the area of sensors and gauges on-board ships and submarines. If these are connected wirelessly, a huge amount of cables are eliminated and more user mobility is gained.

This thesis studies the theories and principles of Bluetooth technology and discusses the approaches of connecting Bluetooth to sensors and gauges. Some of the Bluetooth products available in the market were

acquired for testing and evaluation. In the course of the study, it was found that the technology was not mainly developed with sensor and gauge applications in mind. However, integrating sensors with Bluetooth modules can be achieved by one of two approaches. One approach requires an expensive Development Kit and is limited to manufacturers integrating Bluetooth technology into their sensor products in compliance with Bluetooth Specifications. The other inexpensive approach requires custom circuit designing and program coding and is preferred by university researchers.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Motion Tracking, Wireless LAN, Bluetooth Wireless Technology

DESIGN, IMPLEMENTATION, AND TESTING OF A HIGH PERFORMANCE SUMMATION ADDER FOR RADAR IMAGE SYNTHESIS
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This thesis documents the schematic design, simulation, and fabrication mask layout of a high-speed 16-bit summation adder to be integrated into the Digital Image Synthesizer (DIS) Application Specific Integrated Circuit (ASIC). The DIS is a single-chip false target radar image generator to be used in countering wide band imaging radars. The DIS will calculate the false target image in 512 range bins. Each range bit utilizes two identical 16-bit binary adders. The 16-Bit Adder must compute the sum of two 16-bit numbers, providing a 16-bit sum, carry output, and overflow detection bit. The stated goal is for this adder to perform all of these functions in one pipeline stage while being clocked at 600 MHz. The first part of the design process includes an extensive analysis to utilize the fewest gates in designing the simplest adder that can achieve the 600 MHz goal. SPICE net lists are extracted from these schematic designs and simulations conducted to verify logic functionality and propagation speed. Mask layout of the verified design is constructed using a CMOS 0.18 micron process utilizing deep sub-micron technology with six metal interconnect layers. The mask layout design is verified by ensuring all design rule checks (DRC) and layout versus schematic (LVS) checks are satisfied. In addition, conclusions and recommendations are provided to assist other DIS project members in using this adder and the aforementioned design process for additional components of the DIS ASIC.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronics, Computing and Software

KEYWORDS: Electronic Warfare, Radar Imaging, Digital Image Synthesizer Application Specific Integrated Circuit

MICROELECTRONICS REVERSE ENGINEERING: RECOVERING THE METAL 2 LAYER (U)
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The purpose of this research was to further the effort of microelectronics reverse engineering for the Department of Defense (DoD) toward the goal of evaluation and design verification of Integrated Circuits (ICs) fabricated and/or packaged in unclassified foundries. In particular, this research focused on enhancement of Scanning Electron Microscope (SEM) images to allow an accurate Graphical Data Stream II (GDSII) description to be made of the metal 2 (M2) layer of the Integrated Circuit (IC). This goal was accomplished through the use of the Adobe Photoshop tool, applied to three types of SEM images of the

same area on the IC. The images were acquired with a SEM using a Backscattered Electron Detector, an In-Lens Detector, and a Secondary Electron Detector. Procedures for using Adobe PhotoshopTM are detailed in this paper.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes, and Structures

KEYWORDS: Microelectronics Reverse Engineering, Integrated Circuits, INFOSEC, Adobe Photoshop, SEM, RAITH, ESCOSY, GDSII

EVALUATION OF ALTERNATIVE COMMUNICATION SCHEMES USING ENVIRONMENTALLY ADAPTIVE ALGORITHMS

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Time-varying multipath propagation in a shallow underwater environment causes intersymbol interference in high-speed underwater acoustic (UWA) communications. Combating this effect is considered to be the most challenging task requiring large adaptive filters and increasing the computational burden at the receiver end.

This thesis presents results of an in-tank experiment and data analysis performed off-line to examine, evaluate, and compare the robustness of Time-Reversal Approach to Communications (TRAC) and the Matched Environment Signaling Scheme (MESS) in different conditions, such as noise, surface waves and range changes between the receiver and transmitter. Both methods examined can environmentally adapt the acoustic propagation effects of a UWA channel. The MESS method provides a communications solution with increased computational complexity at the receiver end but gives higher data rates and is more robust to the presence of noise, surface waves, and range changes than the TRAC method. On the other hand, the TRAC method manages to accomplish secure communications with low computational complexity at the receiver.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications

KEYWORDS: Time Reversal Acoustics, Acoustic Communications, Acoustic Signal Processing, Acoustic Telemetry

PERFORMANCE AND SPACE BORNE APPLICATION ANALYSIS OF THE HIGHER ORDER CYCLOSTATIONARY BASED CLASSIFIER

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Testing of the Higher Order Cyclostationary Based Classifier (HBC) is conducted to evaluate system operational performance. Utilizing Higher Order Cyclostationary (HOCS) analysis techniques, the HBC is designed to automatically detect and classify communication and radar signals contained in input signal samples. While test results utilizing earlier data were inconclusive on the effectiveness of the system, a more rigorous testing for Binary Phase-Shift Keying (BPSK) modulation scheme is herein carried out. The results of the HBC analysis reveal a system which experiences difficulty in performing modulation detection and classification of the input data at signal-to-noise ratios above 10 dB. The HBC automatic

band-of-interest detector also shows evidence of interfering with accurate signal classification results. Recommended improvements to the algorithms and interface are presented to address these and other observed trends. An application of the HBC system to the Naval Research Laboratory's Pre-Configured Interface Payload (PCIP) program are assessed for space borne testing of the HBC system.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software, Sensors, Modeling and Simulation

KEYWORDS: Cyclostationary, Cyclostationarity, Digital Signals, Signal Classification, Signals Intelligence (SIGINT), Spacecraft Payload Integration, Pre-Configured Interface Payload (PCIP)

PASSIVE TARGET TRACKING WITH UNCERTAIN SENSOR POSITIONS USING WAVELET-BASED TRANSIENT SIGNAL PROCESSING

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This dissertation investigates the problem of tracking a maneuvering target from passive acoustic sensors of uncertain position. A batch oriented maximum a posteriori (MAP) algorithm using an expanded state vector is used to accurately estimate both the sensor's location and target trajectory from the data. Three sensor motion models are developed and compared under a variety of tracking scenarios. Additional tracking improvement is achieved through the use of transient signal processing. Two new wavelet-based time difference of arrival estimation methods are developed and compared to classical techniques. Testing on a variety of transient signals demonstrates that improved performance over the classical methods is achieved. The practicality and viability of the proposed techniques is confirmed through the modification and testing of a state of the art acoustic tracking system.

DoD KEY TECHNOLOGY AREA: Sensors, Target Tracking

KEYWORDS: Target Tracking, Non-Linear Estimation, Wavelet Analysis

POTENTIAL OPERATIONAL APPLICATIONS FOR HIGH POWER MICROWAVES

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This abstract is classified.

DoD KEY TECHNOLOGY AREAS: Human-Systems Interface, Modeling and Simulation

KEYWORDS: HPM Source, Systems, Wideband, IW, IO

PREDICTION OF WIRELESS COMMUNICATION SYSTEMS PERFORMANCE IN INDOOR APPLICATIONS

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Due to a shift in the interest in wireless applications, from outdoor to indoor environments, new modelling solutions had to be designed to account for the immense complexity of the latter. Essentially, two categories of indoor propagation models prevailed until the mid-90s: the empirical and the physical models. They both predicted important characteristics of a given confined environment like the coverage area, transmitted power requirements, number and location of base stations or access points. The implementation of wireless communications systems onboard naval assets is expected to offer numerous advantages and enhance the existing shipboard communications systems. That, in turn, calls for a reliable and cost-effective means of estimating the expected link budget in such environments, especially when the infrastructure in question is yet to be built, as is the case in a ship class under development.

This thesis treats the problem of indoor propagation modeling using the Numerical Electromagnetic Code-Basic Scattering Code (NEC-BSC) and compares the predicted results obtained by this code with actual measurements performed inside a building at the Naval Postgraduate School. A number of important conclusions regarding the validity of NEC-BSC for indoor applications are being reached and some intriguing statistical results are being presented.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Simulation of Signal Propagation, Indoor Radio Propagation, NEC-BSC

MODELING DATA RATE AGILITY IN THE IEEE 802.11a WIRELESS LOCAL AREA NETWORKING PROTOCOL

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The IEEE 802.11a high-speed wireless local area networking (WLAN) protocol does not specify a mechanism for dynamically altering network data rates based on changing link conditions. This thesis first presents a baseline software model of the 802.11a protocol developed using the OPNET simulation tool. The model includes both the medium access control (MAC) and physical (PHY) layers of the standard. Two data rate agility mechanisms are then proposed and analyzed using the model. An infrastructure WLAN implementation of the baseline model is first simulated under standard network conditions to verify its operational characteristics and the results are presented. The model is then used to simulate two data rate agility mechanisms, one based on the link signal-to-noise ratio (SNR) and the other based on the frame loss rate at the transmitting station. Each technique is simulated using an infrastructure WLAN consisting of a fixed access point and a mobile workstation operating with standard network traffic loads. The results indicate that the link SNR is a better decision criterion for data rate agility than the frame loss rate. The design and methodology of this analysis provides insight into dynamic rate agility mechanisms and the criteria that may be used in developing future 802.11a-compliant hardware implementations.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Wireless, WLAN, Wireless LAN, Protocol, OPNET, 802.11a, OFDM, Rate Agility

WEB-BASED TESTING TOOLS FOR ELECTRICAL ENGINEERING COURSES

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This thesis presents a distance-learning tool, which provides a self-sufficient application that allows one to implement online courses for electrical engineering. A major emphasis is placed on replacing simplistic multiple-choice or true-false test questions. A system named, Distance Learning Tools for Online Tests (DLTOT) is designed, modeled and implemented.

The implementation is based on the Java programming language, using Servlets and Java Server Pages (JSP), three-tier technology and Commercial-Off-the-Shelf (COTS) products, namely, an Apache web server, Tomcat Application server, Microsoft Access, Mathematica, WebMathematica and JSP/ Servlet technology.

DLTOT is able to control student access, to allow interaction with the student during the course, and to present a challenging test, which is easily graded by the application itself.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Distance Learning, Distance Learning Tools for Online Tests, DLTOT

DESIGN OF A SYNCHRONOUS PIPELINED MULTIPLIER AND ANALYSIS OF CLOCK SKEW IN HIGH-SPEED DIGITAL SYSTEMS

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Digital systems implemented with high-speed transistor technologies face a variety of design challenges in an effort to keep pace with the accelerating demand for performance. As device switching frequencies climb comfortably into the gigahertz range, clock skew in digital systems threatens to limit the advantages of synchronous pipelined designs. This research investigates the limitations of clock skew on high-speed digital systems by designing and simulating an 8x8 bit synchronous, pipelined multiplier using Indium phosphide (InP), heterostructure bipolar junction (HBT) transistor technology. Fundamentals of circuit analysis and the principles of junction transistor behavior are applied to design an optimal family of logic devices using current-mode logic. All testing and simulation data is based upon results obtained from Tanner SPICE design tools. Using the building blocks of this logic family, an array multiplier is constructed and further configured into five distinct pipeline implementations. By employing a different number of pipeline stages in each implementation, the trade-offs of pipelining are illustrated and clock skew is analyzed at a variety of throughput rates. Finally, the impact of clock skew on throughput performance is quantified and summarized as a reference point for further research into asynchronous control techniques.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Clock Skew, Pipelined Logic Architecture, Current-Mode Logic, Indium-Phosphide Heterojunction Bipolar Transistors, High-Speed Logic

DEVELOPMENT OF AN RF WEAPON USING OPEN SOURCE INTELLIGENCE

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and
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The world's increasing reliance on computers and electronics has made the employment of radio frequency (RF) weapons against electronic systems an attractive concept. Electromagnetic interference (EMI) effects from RF radiation are well known. Recent advances in high-power microwave (HPM) technology and the increasing commercial availability of conventional RF sources have made the development of such systems for other than scientific pursuits not only feasible, but probable.

This thesis explores the technical requirements, costs, and timelines necessary to build such a system. It documents the processes that a team of "non-experts" undertook to design and build a microwave transmitter capable of disrupting unshielded electronic systems. The researchers investigated how to design and build a viable RF weapon capable of use in terrorist applications on a limited budget, with no external guidance from HPM experts, and using only open source information and Commercial-Off-The-Shelf (COTS) technology. This work documents useful sources of information, the development of a preliminary system design, the acquisition of components, and planning for system fabrication, component modification, and integration into a disguised mobile platform.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Radio-Frequency Weapons, High-Power Microwave, Microwave Transmitter, Open Source Intelligence

SURVEY OF EMERGING WIRELESS/PCS TECHNOLOGY AND THE IMPLICATIONS ON FUTURE MILITARY TACTICAL COMMUNICATIONS

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This research evaluates the wireless technologies that are currently available in the commercial sector or that are in development. The objective is to evaluate the suitability of using the technologies as a viable communication vehicle for the United States Marine Corps, specifically for use by the Intelligence and Information Operations communities. Subjects addressed include cellular/personal communications services (PCS) technology currently available and in development. Also included are potential applications by the USMC, strengths and limitations as they relate to Intelligence and Information Operations, and relationships of cellular and PCS technologies. As a final point, recommendations for categorization of cellular/PCS technologies by radio frequency spectrum and wireless service are incorporated.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Intelligence, Information Operations, Personnel Communication Services, PCS, Cellular/PCS

MEASUREMENTS AND MODELING ENHANCEMENTS FOR THE NPS MINIMUM RESOLVABLE TEMPERATURE DIFFERENCE MODEL, VISMODII

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Minimum Resolvable Temperature Difference (MRTD) measurement has long been used to describe the performance of thermal imaging systems. Computer models such as U.S. Army's FLIR92, that were developed to predict the MRTD, were reported to have deficiencies in dealing with sampling and aliasing effects. The models also include assumptions regarding the observer recognition process and therefore cannot predict the MRTD of an imager that incorporates an "objective" automatic target recognition device instead of a "subjective" human observer. The Visibility Model II developed for second generation thermal imaging systems at the Naval Postgraduate School (NPS) in the mid 90s takes sampling and aliasing issues into account and makes no assumptions about the observer. Modeling enhancements in VISMODII and its extension to predict objective MRTD are proposed and tested in this thesis. A parallel thesis at the NPS has shown that aliasing effects on image appearance are fundamentally different from noise. The improved VISMODII model accounts for the fact that unlike noise, aliasing may have a visual enhancing effect and therefore may lower MRTD. Experiments were conducted to measure subjective and objective MRTD. Experimental results demonstrated that the VISMODII model successfully predicts the MRTD both for the subjective and the objective schemes.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Thermal Imaging Systems, Minimum Resolvable Temperature Difference, MRTD, Visibility Model II, VISMODII

PERFORMANCE OF SERIALLY CONCATENATED CONVOLUTIONAL CODES WITH BINARY MODULATION IN AWGN AND NOISE JAMMING OVER RAYLEIGH FADING CHANNELS

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In this dissertation, the bit error rates for serially concatenated convolutional codes (SCCC) for both BPSK and DPSK modulation with different channel conditions and with (and without) spread spectrum are considered. For low signal-to-noise ratios, simulation results are used, while for higher signal-to-noise ratios, an average upper bound is developed to illustrate the achievable performance of SCCC. The theoretical bounds for SCCC BPSK and SCCC DPSK with AWGN, noise jamming, Rayleigh fading, and spread spectrum are developed, analyzed, and compared with simulation results. The differences in performance between SCCC BPSK and SCCC DPSK are described. Implications for the military communications user and jammer are also discussed.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Serially Concatenated Convolutional Codes, SCCC, BPSK Modulation, DPSK Modulation, Military Communications

AUTOMATED SOFTWARE INTERFACE BETWEEN CEPXS AND SPICE

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Special purpose computer programs are essential to the design of semiconductor circuits that might be subjected to nuclear radiation either from the co-location to radiation sources or from the circuit being used in the space environment. Two such computer programs are the Coupled Electron-Photon Cross Section (CEPXS) and the Simulation Program with Integrated Circuit Emphasis (SPICE). This thesis describes the design and implementation of ASICS, an Automated Software Interface between CEPXS and SPICE (ASICS), which can be used to extract data automatically from the CEPXS output and modify a SPICE circuit description for analysis of potential radiation effects. Historically, this SPICE circuit description modification has been done manually. However, the complexity of large-scale integrated circuits and electronic systems dictates an automated interface between these two programs.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics, Modeling and Simulation

KEYWORDS: Automated Software Interface, CEPXS, SPICE, ASICS, Coupled Electron-Photon Cross Section, Nuclear Radiation Effects, Space Radiation Effects, Radiation-Induced Parasitic Current, Semiconductor Devices

QUANTIFYING THE EFFECT OF CRYPTOLOGY AS A DECISION MAKING TOOL FOR THE NAVAL WARFIGHTER

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This abstract is classified.

DoD KEY TECHNOLOGY AREAS: Other (Information Superiority)

KEYWORDS: Cryptology, Signals Intelligence

AN INVARIANT DISPLAY STRATEGY FOR HYPERSPECTRAL IMAGERY

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Remotely sensed data produced by hyperspectral imagers contains hundreds of contiguous narrow spectral bands at each spatial pixel. The substantial dimensionality and unique character of hyperspectral imagery requires display techniques that differ from traditional image analysis tools.

This study investigated the appropriate methodologies for displaying hyperspectral images based on the physical principles of human color vision and a generalized set of linear transformations. Principal components (PC) analysis is a powerful tool for reducing the dimensionality of a data set, and PC-based strategies were explored in creating a broadly applicable image display strategy. It is shown that the invariant display strategy and generalized eigenvectors developed within this study offer a first look capability for a wide variety of spectral scenes. PC transformations utilizing this generalized set of eigenvectors allow for 'real time' initial classification. Detailed investigation of the relationship between the

PC eigenvectors and dissimilar image content shows that this strategy is robust enough to provide an accurate initial scene classification.

DoD KEY TECHNOLOGY AREAS: Sensors, Human Systems Interface

KEYWORDS: Spectral Imagery, Display Strategies, Colorimetric Representations, Hyperspectral Analysis

THERMINATOR 2: DEVELOPING A REAL TIME THERMODYNAMIC BASED PATTERNLESS INTRUSION DETECTION SYSTEM

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A novel system for conducting non-signature based, or patternless, intrusion detection of computer networks is presented. This system uses principles of thermodynamics to model network conversation dynamics. A notion of baseline operating conditions is developed by observing the properties of entropy, energy and temperature within the system. Perturbations in these properties are considered potential intrusions for further investigation. This thesis focuses on the design and architecture of this system. System functions are decomposed into a network sensing device, a real-time processing component and a forensics component. A mechanism for forwarding and storage of sensed data is developed and discussed. Similarly, a novel three-dimensional display technique and the data structure that allows direct access of raw packet information from energy levels within this display is constructed and discussed. A system configuration language is defined and presented and additional tools for follow-on forensic analysis are developed. Finally, examples of valid intrusions and other network perturbations in real traffic collected in Department of Defense network operation center backbones are presented. Preliminary results indicate this system has significant potential for revealing anomalies in large network systems.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Intrusion Detection, Thermodynamics, High-Speed Networking, Network Sensing Device

THE DESIGN AND IMPLEMENATION OF A REAL-TIME DISTRIBUTED APPLICATION EMULATOR

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This thesis details the engineering, design and implementation of a real-time, distributed, application emulator system (AE system). The project had two main goals for the tool: emulation of real-time distributed systems, and as a programmable resource consumer. The AE system is currently being used in the HiPer-D test bed to activate a resource leveling tool that monitors several software components for real-time response. The AE system is highly flexible and can be used in the context of a variety of network

topologies and system loading options. The results presented show that the AE system also emulates distributed systems.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Emulation, Real-Time Benchmarks

DEVELOPING ARTICULATED HUMAN MODELS FROM LASER SCAN DATA FOR USE AS AVATARS IN REAL-TIME NETWORKED VIRTUAL ENVIRONMENTS

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With the continuing gain in computing power, bandwidth, and Internet popularity, there is a growing interest in Internet communities. To participate in these communities, people need virtual representations of their bodies, called avatars. Creation and rendering of realistic personalized avatars for use as virtual body representations is often too complex for real-time applications such as networked virtual environments (VE). Virtual Environment (VE) designers have had to settle for unbelievable, simplistic avatars and constrain avatar motion to a few discrete positions.

The approach taken in this thesis is to use a full-body laser-scanning process to capture human body surface anatomical information accurate to the scale of millimeters. Using this 3D data, virtual representations of the original human model can be simplified, constructed and placed in a networked virtual environment.

The result of this work is to provide photo realistic avatars that are efficiently rendered in real-time networked virtual environments. The avatar is built in the Virtual Reality Modeling Language (VRML). Avatar motion can be controlled either with scripted behaviors using the H-Anim specification or via wireless body tracking sensors developed at the Naval Postgraduate School. Live 3D visualization of animated humanoids is viewed in freely available web browsers.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Motion Tracking, Inertial Sensors, Human Avatar, Virtual Environments

2-D MODELING OF GAN HEMTS INCORPORATING THE PIEZOELECTRIC EFFECT

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Second Reader: Harry Dietrich, Naval Research Laboratory

Gallium Nitride (GaN) High Electron Mobility Transistors (HEMTs) are radio frequency power amplifiers that promise to revolutionize the capability of Navy radar systems. The Office of Naval Research is currently funding basic research of developing microwave power amplifiers for use in future radar systems. This thesis incorporates piezoelectric (PZ) equations in the Silvaco AtlasTM software for modeling GaN/AlGaN structures. The PZ effect enhances a two dimensional electron gas at the GaN/AlGaN interface due to stress induced polarization.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes, and Structures, Modeling and Simulation

KEYWORDS: Gallium Nitride, High Electron Mobility Transistor, Piezoelectric Effect

FEASIBILITY ANALYSIS AND DESIGN OF A FAULT TOLERANT COMPUTING SYSTEM: A TMR MICROPROCESSOR SYSTEM DESIGN OF 64-BIT COTS MICROPROCESSORS

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The purpose of this thesis is to analyze and determine the feasibility of implementing a fault tolerant computing system that is able to function in the presence of radiation induced Single Event Upsets (SEU) by using the Triple Modular Redundancy (TMR) technique with 64-bit Commercial-off-the-Shelf (COTS) microprocessors.

Due to the radiation environment in space, electronic devices must be designed to tolerate the radiation effects. While there are radiation-hardened devices that can tolerate radiation effects, they offer lower performance and higher cost than COTS devices. On the other hand, COTS devices offer lower cost, orders of magnitude higher performance, shorter design time and better software availability and compatibility. However, COTS devices are susceptible to the radiation effects. In order to use COTS devices in space environment, a fault tolerance technique such as TMR needs to be implemented.

This thesis presents the design and analysis of a TMR 64-bit COTS microprocessor implementation. The system incorporates three 64-bit microprocessors, the memory system including SRAM and PROM memory modules and the programmable logic devices that are used to implement the TMR technique. The validity of the design is verified by the timing analysis conducted on read and write operations.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Electronics

KEYWORDS: Fault Tolerant Computing, Triple Modular Redundancy (TMR), Commercial-off-the-Shelf (COTS) Devices, Single Event Upsets (SEU)

A PATHFINDER FOR A MULTI-INT INFORMATION ARCHITECTURE

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Today's intelligence data management systems are not scalable and flexible enough to meet 21st century warfighter requirements. There is little or no information sharing between the producers of intelligence, perpetuating them as islands (stovepipes) of information. Web technologies offer an improvement over existing intelligence information management systems by providing loosely-coupled connectivity through the use of hypertext transfer protocol (HTTP) and markup language (HTML). But web-based implementations still fall far short of satisfying the majority of requirements posed by intelligence community users. What is needed is a flexible distributed architecture that leverages existing assets and the benefits of web technologies, while providing needed improvements that better address the need for multi-intelligence interoperability.

This thesis applies a systematic requirement-driven approach to define a pathfinder for a multi-intelligence information architecture. The pathfinder concept is discussed as a necessary acquisition tool to help bound and scale a realistic solution. Key enabling information technologies are evaluated and recommended as a foundation for implementation. A case study is presented to show proof-of-concept and progress toward achieving a multi-intelligence information architecture.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Human Systems Interface, Other (Information Technology)

KEYWORDS: Enterprise Computing, Object-Oriented Systems, Distributed Processing, Common Object Request Broker Architecture (CORBA), Java, Extensible Markup Language (XML), Object Databases, Ontology

WEARABLE HF ANTENNA FOR NAVAL POSTGRADUATE SCHOOL COMWIN SYSTEM

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Researchers at the Naval Postgraduate School (NPS) have proposed a Combat Wear Integration (COMWIN) antenna system that includes three separate antennas for the man-portable implementation of the Joint Tactical Radio System (JTRS). The COMWIN system incorporates wideband antennas into the warrior's combat clothing in order to make the radio operator indistinguishable on the battlefield. The three antennas cover the frequency ranges: 2-30 MHz, 30-500 MHz, and 500-2000 MHz. This thesis describes the man wearable HF antenna designed to operate from 2-30 MHz for use by dismounted warriors in all combat environments. The antenna was designed and its performance predicted using Ansoft's High Frequency Structure Simulator (HFSS) and Nittany Scientific, Inc.'s Graphical Numerical Electromagnetics Code (GNEC). Measurements of the prototype showed good agreement with theoretical predictions. The HF antenna must operate with an inductive Automatic Tuning Unit (ATU). Coupling between the antenna and a human body effects antenna input impedance. Placing the antenna on a human limits the antenna conductor electrical path length at the frequencies of operation. For the optimum antenna location, an analysis of the antenna design is conducted for seven different types of soil. The antenna must operate from 2-30 MHz with a Voltage Standing Wave Ratio (VSWR) less than three for a 50 (coaxial cable, have low visual signature, be vertically polarized, have coverage from 0 to 60 degrees above the horizon and 0 to 360 degrees in azimuth. Input impedance and radiation patterns are determined for the antenna using the GNEC and HFSS.

DoD KEY TECHNOLOGY AREAS: Battle Space Environments, Clothing, Textiles and Food, Command, Control and Communications, Electronics, Electronic Warfare, Modeling and Simulation, Manufacturing Science and Technology

KEYWORDS: HF Antenna, Wearable Antenna, Numerical Electromagnetics Code (NEC), Method of Moments, Combat Wear Integration

SECURITY OF CODE-DIVISION MULTIPLE ACCESS (U)

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With the shift of the defense industry from developing Government-off-the-shelf (GOTS) equipment to engineering current and new commercial products and technology into pre-existing and new government communication products along with the growing popularity of wireless mobile communication, a look at the security of code-division multiple access (CDMA) - a current and future wireless multiple access technology - in the context of the tactical battlefield is the focus of this paper.

After identifying the security weaknesses of CDMA in the context of the Global Information Grid (GIG) - an environment to support tactical communication networks - technologies to minimize or overcome the vulnerabilities are presented for the tactical commander to employ or implement.

Additionally, the effect of pulse jamming on a IS-95 like CDMA system is analyzed. Graphs are provided to show how the probability of bit error due to the pulse jammer is directly influence by the power of the transmitter.

DoD KEY TECHNOLOGY AREAS: Other (Global Information Grid, Wireless Communication)

KEYWORDS: Code-Division Multiple Access (CDMA), Global Information Grid (GIG), Tactical Battlefield, Security Services, Hard Decision Decoding

OPTIMIZATION OF MULTIPLE PLATFORM PRECISION GEOLOCATION THROUGH COMPUTER SIMULATION

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The fundamental mathematical relationships that govern Time Difference of Arrival (TDOA) geolocation suggest that to reduce the positional uncertainty in the target, the baseline between the two collectors can be lengthened. A multiple-platform precision geolocation system is modeled using Operational Performance Simulation (OPS) software and tested with various baseline lengths to determine the impact on system performance.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Space Vehicles, Command, Control and Communications, Electronic Warfare, Sensors, Modeling and Simulation

KEYWORDS: Computer Simulation, Unmanned Aerial Vehicles, Precision Geolocation

PERFORMANCE ASSESSMENT OF AN INTRAPULSE TECHNIQUE TO IDENTIFY AND DEINTERLEAVE RADAR SIGNALS

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The Wilson Advanced Specific Emitter Identification (SEI) Algorithm with Adaptive Thresholds is evaluated using live radar data. The objective is to determine performance of the algorithm in a low signal to noise ratio (SNR) environment, compare the performance to that of an intrapulse frequency based approach and explore implementation of the algorithm in deinterleaving applications. Utilizing unintentional Phase Modulation on the Pulse (PMOP) as an identification feature and adaptive thresholds in the classifier, the algorithm is designed to identify radar signals based on single pulse analysis. Earlier efforts have demonstrated the efficacy of using PMOP versus frequency modulation on the pulse (FMOP) and the technique's effectiveness against lab generated signals in low SNR conditions. This work tests the technique utilizing live radar data. Live radar data of marine navigation radars with similar conventional parameters collected by the Naval Research Laboratory served as the data set for the test. The SEI results of the live radar testing confirm the algorithm performs well on a single pulse basis in relatively low SNR environments. Additionally, use of PMOP in the algorithm results in a 3-4 dB SNR performance gain over FMOP. A conceptual deinterleaving architecture, which incorporates the technique, is developed.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communication, Electronics, Electronic Warfare, Sensors, Space Vehicles

KEYWORDS: Specific Emitter Identification, Deinterleaving, Intrapluse, Unintentional Modulation on the Pulse, Pattern Recognition, Signal Classification, SNR

MEANS OF COVERT COMMUNICATIONS

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Steganography is the "art" of hiding information so that the information's very existence is not detected. As a method of covert communications, steganography is used to hide information within other communications media. This thesis examines the various techniques of hiding information within Local Area Network (LAN) or Wide Area Network (WAN) communications traffic, with special emphasis on typical internetwork traffic using the Transmission Control Protocol (TCP) and Internet Protocol (IP). Current means of steganography within network traffic is limited in terms of throughput and robustness. A novel means of covertly transmitting data within TCP segments is presented which demonstrates how manipulating TCP error handling should increase the effective throughput of covertly transmitted data significantly. A new TCP data hiding application was developed to embed the hidden information into the cover media, and to retrieve the information at the receiving end. A flexible testing architecture was designed and implemented that may also be used to test other steganographic techniques. Error handling techniques for the hidden information were identified for the steganographic protocol, to increase the robustness of the hidden information. Finally, steganalytic techniques and tools have been identified to counter the use of this technique by unfriendly forces.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Local Area Networks, LAN, Wide Area Networks, WAN, Transmission Control Protocol, TCP, Steganography

DESIGN OF MOBILE USER OBJECTIVE SYSTEM (MUOS) HELMET MOUNTED UHF ANTENNA

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The Mobile User Objective System (MUOS) is the Navy's next generation narrowband tactical communication system that will provide a significant increase in capacity and link availability to disadvantaged users, including handheld terminals. Future MUOS antennas will have a receive band of 243 MHz - 270 MHz and a transmit band of 292 MHz - 317 MHz with a voltage standing wave ratio (VSWR) of less than three across both bands. Additionally, the antenna must have a nearly omni-directional radiation pattern above 10 degrees in elevation, be conformal to a U.S. military helmet and have a low profile. In this thesis an antenna was designed that is capable of operating over the entire band 243 MHz to 317 MHz. The antenna performance was optimized for its design restrictions. The antenna was designed and its performance predicted using Ansoft's High-Frequency Structure Simulator (HFSS). The HFSS is based on the Finite-Element Method (FEM).

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Antennas, Tactical Communications System, Mobile User Objective System, MOUS

DESIGN AND EXPERIMENTAL EVALUATION OF AN ELECTRO-OPTICAL, SIGMA-DELTA MODULATOR FOR WIDEBAND DIGITAL ANTENNAS
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Electro-optical sigma-delta ((() analog-to-digital converters (ADCs) use a pulsed laser to oversample an input signal at two Mach-Zehnder interferometer modulators. A fiber lattice accumulator is embedded within a feedback loop around a single-bit quantizer to spectrally shape the quantization noise to fall outside the signal band of interest. Applications of electro-optical ((ADCs include digitizing wideband radio frequency signals directly at an antenna (digital antenna). The design considerations, construction process and experimental evaluation of the electro-optical ?? ADC are presented. The experimental results are compared with a computer model of the electro-optical ???sampling and digitization process.

DoD KEY TECHNOLOGY AREAS: Electronics, Electronics Warfare, Sensors, Other (Electro-Optics)

KEYWORDS: Sigma-Delta, Optical Sampling, Analog-to-Digital Converters, Optical ADC, Electro-Optical, Digital Antennas, Fiber Lattice, Mach-Zehnder Interferometers

EFFECTIVENESS OF THE HARM AS EMPLOYED BY THE F-16CJ AIRCRAFT AGAINST SERBIAN THREAT AND EARLY WARNING RADAR DURING OPERATION ALLIED FORCE
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The purpose of this thesis is to quantify the effectiveness of HARM Employment by F-16CJ aircraft against Serbian Threat and EW radars during OPERATION ALLIED FORCE (OAF) of March-June 99. The effectiveness was determined primarily through the use of "all-source" data to confirm the suppression/damage that target radars may have suffered and to assess general radar activity impacts as a whole during the conflict. The factors that enhance or degrade HARM effectiveness were also investigates as well as strike aircraft impacts where possible. Due to the impact that fog of war has on obtaining specific technical data, the emphasis of the report is on the apparent effect of the HARM on the enemy air defenses during the course of a mission (and campaign) and not the technical aspects of HARM performance during an engagement. However, modeling of several of the individual mission incidents was accomplished. In these cases, MESA 5.1.3 (Model for Electronic Support and Attack) was used to model the airborne receivers/ground emitters, calculate propagation losses, and verify scenario geometry to determine signal strength levels at the airborne receivers of interest.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: F-16CG, High-Speed Anti-Radiation Missile, Air War Over Serbia

VULNERABILITY ASSESSMENT THROUGH PREDICTIVE MODELING OF IEEE 802.11 STANDARD WIRELESS LOCAL AREA NETWORKS

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The development of the IEEE 802.11 standard for wireless local area networks (WLANs) has greatly accelerated the commercial development of wireless technology for enterprise network solutions. Government and military organizations are also benefiting from the competition and interoperability fostered under the international standard. Given the decreasing cost, and proliferation of wireless networking technology, organizations are foregoing the expansion of cumbersome ethernet networks, and turning to cheap, available wireless architectures to augment data communication and processing needs.

Wireless technology availability coupled with the U.S. military's trend of looking to commercial-off-the-shelf (COTS) communication and computing solutions necessitate an awareness of the characteristics of WLANs. The argument for research is bolstered when considering how the ease of implementation and low system maintenance costs make it probable that second or third world entities at odds with US interests may use COTS wireless technology. Should the U.S. confront adversaries that have integrated command and control circuits consisting of WLANs, or come under attack from groups that know how to exploit our own, it will be necessary to have analyzed WLAN characteristics.

This thesis intends to research the current industry technology and standards driving WLAN interoperability, and determine which vendor's components are likely to be seen in world markets. Finally, the thesis will analyze a WLAN communications link at NPS to determine feasibility of emissions/intercept field mapping using a modular software and hardware suite.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Electronics, Electronic Warfare, Sensors, Other (Wireless LANs)

KEYWORDS: Wireless Local Area Networks, IEEE 802.11, Exploitation, Vulnerability, Link Analysis, Radio Propagation, Network Security, Information Operations

WIRELESS TECHNOLOGY VIA SATELLITE COMMUNICATIONS FOR PEACEKEEPING OPERATIONS

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How can reliable information be shared amongst international, military, and non governmental organizations in support of peacekeeping operations? This thesis examines a wireless alternative to enhance existing communication infrastructures as a primary means of information exchange. When assessing the need for wireless and making a determination of its use, a study of its markets, trends, future growth, policies, and regulations must be taken into consideration. Wireless technology via satellite communications can offer a great advantage of information exchange for mobility-deployed organizations requiring extensive geographical coverage such as peacekeeping operations. With the emergence of higher transmission rates and technological options (i.e. video conferencing, Wide Area Networking, internet accessibility, voice/fax/data transfer, etc.) for satellite communication, the examination of wireless technology and the options it presents becomes paramount. Peacekeeping efforts involve the coordination and collaboration of civilian/military organizations that depend exclusively on information exchange for rapid response and operational readiness. The use for wireless as a necessary communication requirement will aid in the achievement of these objectives.

DoD KEY TECHNOLOGY AREAS: Other (Information Operations)

KEYWORDS: Wireless Technology, Satellite Communications

FEASIBILITY STUDY OF SPEECH RECOGNITION TECHNOLOGIES FOR OPERATING WITHIN A MEDICAL FIRST RESPONDER'S ENVIRONMENT

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This thesis was designed to address some of the issues facing the medical First Responder who is continually tasked with providing care within multi-national environments. Currently, there are no established billets or quota requirements at the Defense Language Institute Foreign Language Center for Navy Corpsmen for the purposes of foreign language education prior to an overseas assignment or deployment.

The primary Speech Recognition (SR) device used in this study was the Voice Response Translator (VRT). Navy Corpsmen and Army Medics were asked to evaluate the VRT's capabilities in assisting with non-English speaking patient assessments. Other SR assisted technologies available to overcome some of the burden of providing healthcare in a foreign language environment were also studied. The results of this feasibility study show that SR assisted technologies are a viable tool available for operation within a medical First Responder's environment.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel, and Training, Computing and Software

KEYWORDS: Speech Recognition, Machine Translation, Field Medicine, Medical

CLASSIFICATION OF DIGITAL MODULATION TYPES IN MULTIPATH ENVIRONMENTS

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As the expansion of digital communication applications still continues, the need for automated classification of digital modulation types increases. This study attempts to give a partial solution to this problem by proposing a classification scheme which identifies nine of the most popular digital modulation types; namely 2-FSK, 4-FSK, 8-FSK, 2-PSK, 4-PSK, 8-PSK, 16-QAM, 64-QAM and 256-QAM. Higher-order statistics parameters are selected as class features, and a hierarchical neural network-based classifier set-up proposed for the identification of all modulation types considered except those within the M-QAM family. Specific M-QAM types identification is obtained via equalization-based schemes. This study considers the effects due to real-world multipath propagation channels and additive white Gaussian noise. Results show a consistent overall classification performance of at least 68% for severe multipath propagation models and for SNR levels as low as 11dB.

DoD KEY TECHNOLOGY AREAS: Electronics, Electronic Warfare

KEYWORDS: Digital Modulations, Propagation Channels, Moments, Cumulants, Neural Networks, Classification

COMPLETION AND TESTING OF A TMR COMPUTING TESTBED AND RECOMMENDATION FOR A FLIGHT-READY FOLLOW-ON DESIGN

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This thesis focuses on the completion and hardware testing of a fault tolerant computer system utilizing Triple Modular Redundancy (TMR). Due to the radiation environment in space, electronics in space applications must be designed to accommodate single event phenomena. While radiation hardened processors are available, they offer lower performance and higher cost than commercial off the shelf processors. In order to utilize non-hardened devices, a fault tolerance scheme such as TMR may be implemented to increase reliability in a radiation environment. The design that was completed in this effort is one such implementation.

The completion of the hardware design consisted of programming logic devices, implementing hardware design corrections, and the design of an overall system controller. The testing effort included basic power and ground verification checks to programming, executing, and evaluating programs in read only memory. During this phase, additional design changes were implemented to correct design flaws.

This thesis also evaluated the preliminary design changes required for a space implementation of this TMR design. This included design changes due to size, power, and weight restrictions. Additionally, a detailed analysis of component survivability was performed based on past radiation testing.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software, Electronics

KEYWORDS: Fault Tolerant Computing, Triple Modular Redundancy (TMR), Commercial-off-the-Shelf (COTS) Devices, Single Event Upsets (SEU)

COMPUTER NETWORK DEFENSE: A SURVEY OF NETWORK TRACING TECHNIQUES

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With the growth of the Internet, the World Wide Web, and digital networks throughout the Department of Defense (DoD), the amount of information and resources available nearly instantaneously greatly impacts operations within DoD and each service. Because of this impact, the reliability, integrity and availability of data has become critical to the success of the Department's mission. As part of the security posture of DoD, a layered defense is integrated into its digital networks, which is implemented as a passive measure to meet DoD's security needs. These defenses, however, are able to identify the origin of attacks only after traditional investigative techniques are employed. This thesis looks at al of the research being conducted in academia, in the commercial sector, and within the government to address the traceback problem, the means to identify an attacker's Internet source location via automated methods.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Sensors, Other (Computer Security, Information Operations)

KEYWORDS: Traceback, CNA, CNE, CND, Network Security, DNO, IO

AN IMPROVED MAGNETIC, ANGLE RATE, GRAVITY (MARG) BODY TRACKING SYSTEM
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Electrical Engineer-June 2001
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This thesis proposes the design of an improved Magnetic, Angular Rate, Gravity (MARG) Body Tracking System. The current MARG Body Tracking System is limited to tracking three limb-segments. The MARG sensors are physically connected to a desktop computer by cables.
In this thesis, a multiplexing circuit was implemented to allow tracking of 15 limb-segments. Processing was moved from a desktop computer to a wearable computer and wireless communication was implemented using an IEEE 802.11b spread spectrum wireless LAN. The resultant system is able to track the entire human body and is untethered. The range of the system is the same as that of the wireless LAN which can be extended with the use of repeaters. This thesis work will ultimately allow human insertion into virtual environments for training and other applications.

DoD KEY TECHNOLOGY AREA: Computing and Software, Human System Interface, Sensors

KEYWORDS: Human Body Tracking

AN ARCHITECTURE FOR ANALYSIS AND COLLECTION OF RF SIGNALS USED BY HAND-HELD DEVICES IN COMPUTER COMMUNICATIONS
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Second Reader: Murali Tummala, Department of Electrical and Computer Engineering

This thesis studies the wireless communications aspects of an Internet-connected hand-held device. It reviews the multipath effects of RF propagation and provides a detailed analysis of the Mobitex network protocols. Field experiments were conducted to measure the signal strength of indoor and outdoor reception. A framework for using real-time wireless communications analysis equipment for the collection of this RF signal is designed and discussed. Expected results from the collection of this signal data are presented.

DoD KEY TECHNOLOGY AREA: Other (Wireless Communications, Computer Communications)

KEYWORDS: Wireless Communications, Mobile Data, RF Signal

RADAR TARGET IMAGING USING TIME-REVERSED PROCESSING
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This thesis investigates and demonstrates the workability of the time-reversed process for radar imaging applications, particularly, for bi-static or multi-static radars. One benefit of the time-reversed process is its ability to reduce the calculation to determine the targets' shape. The finite-difference-time-domain (FDTD) method is used to demonstrate the time-reversed process.

Following an overview and description of the principles of the time-reversed process, the FDTD method is applied to the wave equation and the time reversed-process in 2-D space. The FDTD numerical model is developed and used for producing fundamental examples on conducting targets. The examples reveal that the time-reversed process can be employed for radar imaging within certain constraints. Finally, conclusions regarding the time-reversed-process are presented and recommendations for future research are provided.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Time-Reversed Electromagnetics, Finite-Difference-Time-Domain, FDTD, Radar Targeting Imaging

IMPLEMENTING THE CROSS AMBIGUITY FUNCTION AND GENERATING GEOMETRY-SPECIFIC SIGNALS

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Second Reader: Ralph D. Hippenstiel, Department of Electrical and Computer Engineering

The first purpose of this thesis is to implement an efficient Cross Ambiguity Function (CAF) algorithm to compute the Time Difference of Arrival (TDOA) and Frequency Difference of Arrival (FDOA) between two sampled signals. Two CAF-related MATLAB functions were written and analyzed. One implements a "coarse" mode and a "fine" mode to accurately compute the TDOA and FDOA. The second plots different views of the resulting three-dimensional CAF surface.

The second purpose is to develop a program to generate geometry-specific signals. Some software packages can artificially embed constant TDOAs and FDOAs between two signals. In real-world emitter-collector geometries (one emitter and two separate collectors), however, movement of the emitter and/or collectors causes time-varying TDOAs and FDOAs. A MATLAB function was written to generate pairs of Binary-Phase-Shift-Keying signals according to user-defined signal parameters and Cartesian geometries. The resulting signal pairs have realistic TDOAs and FDOAs that vary with time according to geometry and relative motion.

Several signal pairs with different geometries are generated and input into the CAF functions, and the results are compared with theoretical TDOA and FDOA calculations. Finally, signals with low signal-to-noise ratios are generated to evaluate the CAF's ability to find Low Probability of Detection signals.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Signals Intelligence, Geometry-Specific Signals

RADIATION EFFECTS ON InGaAs p-i-n PHOTODIODES

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This thesis identifies, characterizes, and identifies a method to predict the dark current degradation of InGaAs p-i-n Photodiodes caused by exposure to 55 MeV protons, 12 MeV protons, and 90 MeV electrons. Experimental proton and electron fluence levels (particles/cm2) were calculated and correlated to fluence levels for a 1 MeV neutron in silicon by equating the amount of physical damage incurred within the device. Physical damage was quantified as a displacement damage dose (Dd), which is simply the fluence level multiplied by the appropriate value for the material's non-ionizing energy loss (NIEL). Photodiodes were then irradiated and dark current data was collected. The resulting data were fitted into the three-term

diode equation, and current coefficients were obtained. Proton data were used to document device performance, and to examine the relationship between fluence levels and changes in the current coefficients. Additionally, these data were used to verify that it is appropriate to use NIEL and Dd for the correlation of 55 MeV and 12 MeV protons. Electron data were also used to document device performance, but failed to demonstrate the ability of NIEL and Dd to accurately match the predicted changes in device performance caused by 90 Mev electrons and 55 MeV protons.

DoD KEY TECHNOLOGY AREA: Electronics, Other (Radiation Effects)

KEYWORDS: Radiation, InGaAs Photodetectors

ANALYSIS OF INTEL IA-64 PROCESSOR SUPPORT FOR A SECURE VIRTUAL MACHINE MONITOR

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Second Reader: Frederick W. Terman, Department of Electrical and Computer Engineering

This thesis explores the Intel IA-64 architecture's capability to support a secure virtual machine monitor. The major mission of a virtual machine monitor is to provide an execution environment identical to the real machine environment for virtual machines. A VMM duplicates the real resources of a processor for virtual machines while making a virtual machine think that it is running on a real machine. As a result, a virtual machine monitor allows multiple virtual machines to run concurrently on the same machine.

A secure VMM on the Intel IA-64 architecture would offer several benefits. A secure VMM would ensure that security policy is enforced by constraining information flow between the supported virtual machines. This would provide PC users with a more secure environment in which to run COTS operating systems.

The Intel IA-64 architecture was analyzed to determine if it is virtualizable. Three types of virtual machine monitors and their hardware requirements have been defined. The IA-64 architecture was mapped to these hardware requirements. Analysis showed that the IA-64 architecture meets three main hardware requirements. However, IA-64 instruction set contains 18 sensitive unprivileged instructions. These instructions prevent the IA-64 architecture from being used for a Type I VMM. Several virtualization techniques used in some architectures are discussed to determine if these techniques could be applicable to virtualization of the IA-64 architecture.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Virtual Machines, Virtual Machine Monitors, Intel IA-64 Architecture

THE NPS VIRTUAL THERMAL IMAGE PROCESSING MODEL

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A new virtual thermal image-processing model that has been developed at the Naval Postgraduate School is introduced in this thesis. This visualization program is based on an earlier work, the Visibility MRTD model, which is focused on predicting the minimum resolvable temperature difference (MRTD). The MRTD is a standard performance measure for forward-looking infrared (FLIR) imaging systems. It takes into account thermal imaging system modeling concerns, such as modulation transfer functions (MTFs), sampling, aliasing and noise, and provides virtual visual images that are associated with the thermal imaging system being modeled. This capability of the model allows the user to virtually evaluate the effects

of component variation, noise, sampling and aliasing on the final four-bar image. The analysis demonstrated that aliasing effects in thermal images of four-bar patterns cannot, in general, be adequately modeled as noise. For example, the simulation experiments showed that under the right conditions aliasing can create a noticeable contrast enhancement in the output images.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Thermal Image-Processing Model, Visibility MRTD, Minimum Resolvable Temperature Difference, MRTD

ANALYSIS OF M-JPEG VIDEO OVER AN ATM NETWORK

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With the emergence of a network-centric philosophy of military operations, the behavior of video applications over resource-constrained information networks is of increasing interest in the development of future naval information systems. This thesis analyzes the impact of compression, delay variance, and channel noise on perceived networked video quality using commercially available off-the-shelf equipment and software. An experimental packet video laboratory is developed for quantitative and qualitative analysis of Motion JPEG video transmitted over a constrained Asynchronous Transfer Mode (ATM) network. Bandwidth profile analysis for various types of video points out the impracticality of ATM bandwidth and cell delay management algorithms for mainstream video applications such as entertainment and distance learning. Additionally, functional limitations of individual laboratory components are identified for consideration in the planning of future experimental work.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communication

KEYWORDS: ATM, Protocol, Motion JPEG, Packet Video, Communications

VLSI DESIGN OF SINE/COSINE LOOKUP TABLE FOR USE WITH DIGITAL IMAGE SYNTHESIZER ASIC

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This thesis documents the circuit design, simulation, and integrated circuit mask layout of the sine/cosine Lookup Table (LUT) to be integrated into the Digital image Synthesizer (DIS) ASIC. The DIS is a single-chip false target radar image generator to be used in countering wide-band imaging radars. The purpose of the LUT is to take the 5-bit input from the phase rotation adder of the DIS and digitally generate the In-phase (I) and Quadrature (Q) signals to form the false target radar returns.

The first part of the design includes an extensive analysis to determine the optimal resolution for the LUT ROM. The design proceeds with the circuit design of an 8-bit resolution sine/cosine LUT. SPICE Net-lists are generated from the circuit schematics in order to run simulations to prove logic validity and determine time delays. Mask layout of the verified design is constructed using a CMOS 0.18 micron process utilizing deep sub-micron technology. Finally, the mask layout design is verified by ensuring all design rule checks (DRCs) and layout versus schematic (LVS) checks are satisfied. In addition, recommendations are provided to assist other DIS project members in effectively using the aforementioned layout process in the continuing design and layout of the DIS ASIC.

DoD KEY TECHNOLOGY AREAS: Electronics, Electronic Warfare

KEYWORDS: Digital Image Synthesizer, VLSI, ASIC, CMOS, Lookup Table, ROM, Chip Design

AN INVARIANT DISPLAY STRATEGY FOR HYPERSPECTRAL IMAGERY

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Remotely sensed data produced by hyperspectral imagers contains hundreds of contiguous narrow spectral bands at each spatial pixel. The substantial dimensionality and unique character of hyperspectral imagery requires display techniques that differ from those provided by traditional image analysis tools. This study investigated techniques enabling the display of hyperspectral images without the interference of in-scene characteristics that lead to biased representations depending on the content of every image under analysis. Utilizing the Principal Components Analysis transformation it is possible to simplify the representation requirements while maintaining the information contained in the scene. The introduction of an external eigenvector, containing few spectral characteristics, into the original scene data removes most of the spectral bias allowing for an accurate detection of the constituent elements. The subsequent shift of the resulting data to match the respective hue directions in the dataspace allows for image color fidelity based on the true composition of the image while all the environmental influence has been removed and the final outcome is readily perceived by the human vision.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Hyperspectral Imaging, Image Analysis

ANALYSIS OF MULTIRATE RANDOM SIGNALS

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Multirate digital signal processing techniques have been developed in recent years for a wide range of applications, such as speech and image compression, digital audio, statistical and adaptive signal processing, numerical solution of differential equations and many other fields.

The purpose of this thesis is to extend optimal filtering techniques to random signals sampled at different rates. In particular, two major problems are considered: (1) optimal filtering of two sets of observations at different sampling rates as a multirate Wiener filter, and (2) linear prediction on successive samples of a random process. In the first problem it is shown that the standard Wiener filter can be extended to the multirate case, while preserving its optimality. In the second problem it is shown that multichannel linear prediction on successive samples of a process, yields orthogonal uncorrelated innovations.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software, Sensors

KEYWORDS: Multirate Signal Analysis, Estimation, Wiener Filter

TIME DELAY ESTIMATION FOR UNDERWATER SIGNALS AND APPLICATION TO LOCALIZATION

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The problem of time difference of arrival (TDOA) is important in underwater acoustics for both passive and active sonar. Classical approaches to this problem are based on generalized cross-correlation (GCC) methods implemented in the frequency domain. After appropriate weighting of the cross spectral data in the frequency domain, an inverse discrete Fourier transform (IDFT) is performed and the peak of the resulting GCC function is located in the time domain.

This thesis shows that the cross-spectrum of the data satisfies an appropriate signal subspace model; therefore the IDFT can be replaced with a signal subspace technique such as MUSIC. The result is an enhanced ability to locate the peak. Further, application of methods such as root-MUSIC or ESPRIT produce direct numerical estimates for TDOA without the need to search for a peak. Results are presented for an extensive set of simulations using both synthetic signal data and data from a ocean acoustic propagation model (MMPE). Results are further presented for an application of the new method to target localization and tracking. In all cases results are compared using both the new methods and the classical methods.

DoD KEY TECHNOLOGY AREAS: Other (Underwater Acoustics, Signal Processing)

KEYWORDS: Time Difference of Arrival, Subspace Methods, Generalized Cross-Correlation, Localization

ULTRA-WIDEBAND, ANTENNA DESIGNS FOR MILITARY VEHICLE APPLICATIONS

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The commanding need to operate ultra-wideband communication systems in tactical environments, especially in military vehicle applications, will require efficient, omni-directional broadband antennas with a low profile. In the case of the LAV-C2 vehicles, the desired antenna should ideally operate from 30-450 MHz with a voltage standing-wave ratio (VSWR) of less than three across the entire band. Additionally, the antenna must be vertically polarized, must be constrained in size and must have a low profile. In this thesis, an antenna was designed that is capable of operating in the frequency range of 47-450+ MHz, covering the whole bandwidth for the AS-3588 monopole antenna and most of the bandwidth for the AS-3916 monopole (whip) antenna, which are both operating on the LAV-C2 vehicles. The antenna performance was optimized for its design restrictions. This thesis also examined the use of dielectric loading in order to minimize the antenna size relative to the operating wavelengths. The antenna was designed and its performance predicted using Ansoft's High-Frequency Structure Simulator (HFSS). The HFSS is based on the Finite-Element Method (FEM). As well, the HFSS assigns material properties, other than only metal, to a structure. This enabled more realistic antenna designs to be simulated. Several versions of the base design were modeled and simulated, and a comparison of their performance is presented.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Electronic Warfare, Modeling and Simulation

KEYWORDS: Ultra-Wideband Antenna, Omni-directional, Low Profile, Vertically Polarized, Ansoft High-Frequency Structure Simulator (HFSS), Dielectric Loading

MODELING TOTAL DOSE RADIATION EFFECTS IN A MULTI-EDGE SOI nMOSFET

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Silicon-On-Insulator (SOI) devices provide inherent radiation-hardness for dose-rate and single-event upset effects that makes them ideally suited for radiation environments such as space. Specifically, the SOI Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET), with its many Si/SiO2 interfaces, is normally only sensitive to total dose radiation effects. This thesis investigates how to model these effects accurately and develops a computer simulation methodology utilizing hole trapping for modeling total dose radiation effects in a SOI semiconductor device. Specifically, a commercial Technology Computer Aided Design (TCAD) application, modified to include total dose radiation effects, is used to simulate an irradiated n-channel, multi-edge SOI MOSFET. The accuracy of the model is evaluated by using the simulation data to calculate simplified radiation induced leakage currents at various radiation dosages and then comparing with experimental measured leakage currents from irradiated devices. Simulation results show that while hole trapping is a dominant mechanism in causing enhanced leakage current at lower dose levels, it cannot solely account for all the enhanced leakage that occurs in a multi-edge device at higher dose levels.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation

KEYWORDS: Electronics, Silicon-on-Insulator (SOI), Modeling and Simulation, Radiation Hardened

MEETING SIGINT CONSTRAINTS IN PACKET TELEPHONY

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An analysis of protocols and standards that govern Voice Over Internet Protocols (VOIP) is presented. Items of specific interest to the Intelligence Community and the Department of Defense are examined and discussed. Research efforts within the Intelligence Community are also detailed.

The recent expansion of Internet Protocol telephony industry completely changes voice service in the commercial communications environment. A forecast of VOIP expansion provides the Intelligence Community an insight into the challenges it faces. Finally, an analysis of identifiers in the field of major protocols is presented. This study concentrates on the H.323 protocol but also addresses the Media Gateway Control Protocol and the Session Initialization Protocol.

Major VoIP industry announcements are summarized. Internet telephony concepts, including a comparison of the major protocols, Internet Protocol telephony integration into networks, and Internet Protocol telephony services are reviewed. Using the information presented in this thesis, the Intelligence Community can gain understanding of VOIP information processing and how to leverage the technology in the emerging Information Age. The advantage that can be gained is vital to the warfighter and joint commanders as they face a different kind of adversary in the Twenty First Century.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications, Computing and Software, Other (Telecommunications)

KEYWORDS: Voice Over Internet Protocol, Signaling System 7, H.323, Public Switch Telephony Network, Internet Protocol

THE DESIGN, SIMULATION, AND FABRICATION OF A VLSI DIGITALLY PROGRAMMABLE GIC FILTER

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In this research, the design, simulation and mask layout for a VLSI Digitally Programmable Generalize Impedance Converter (GIC) Filter is presented. Programmable elements are filter type (low-pass, high-pass, band-pass and notch), center frequency and quality factor. The analog design eliminates the quantization errors, analog-to-digital and digital-to-analog conversion components, and the processing time delay associated with digital signal processing devices. Using a GIC as the basic circuit simplifies topology changes to realize the programmability function and eliminates a problematic component for integrated circuit fabrication, the inductor. Additionally, switched capacitor usage allows the elimination of resistors from the design, another problematic component for integrated circuits. The design was simulated with PSPICE while VLSI mask layout was performed with LASI. The chip has been submitted for fabrication to further research the design of analog VLSI circuits.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: GIC, Analog Filter, VLSI, Switched Capacitor, Programmable Filter

ULTRA-WIDEBAND, COMBAT WEARABLE INTEGRATED (COMWIN) ANTENNA DESIGN FOR THE JOINT TACTICAL RADIO SYSTEM (JTRS)

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The Ultra-Wideband, Combat Wearable Integrated (COMWIN) antenna is a 54 to 500 MHz antenna integrated into the protective flak vest worn by infantry Marines or soldiers. This COMWIN antenna was designed to support the Joint Tactical Radio System (JTRS), and is part of an antenna system developed at NPS that incorporates wideband antennas into combat equipment. The concealed design presented in this thesis would eliminate the traditional visual profile associated with radio operators in infantry units by eliminating the vertical whip antenna. In this thesis, a conformal vest antenna was designed with an approximate 10:1 bandwidth (54-500 MHz). The antenna's performance was predicted through computer simulation. A prototype was built and its performance was measured. Measurements on the prototype showed a good fit with the theoretical predications. The antenna's VSWR is less than 3:1 between 54 and 500 MHz. Simulation results at 54 MHz, 164 MHz, and 500MHz showed that the radiation patterns were omni-directional at lower frequencies and became more directional at higher frequencies, concentrated in the sector from the horizon to 60° elevation.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Communications, Antennas, COMWIN

KALMAN FILTERING OF FDOA/TDOA MISSILE TRACKING SYSTEM
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The accuracy of a tracking system designed to determine the time, space and position information (TSPI) of an airborne missile by detecting its telemetry signal at a number of receiver sites is investigated. Doppler frequency measurements are converted to range differences between the missile and receiver sites, whose locations are known in three dimensions. An algorithm then utilizes these range differences to obtain the missile TSPI. The accuracy of the TSPI is a function of the measurement precision and the signal-to-noise ratio at the receiver sites.

This thesis examines the characteristics of the TSPI accuracy and investigates how a Kalman Filter can be used to enhance the accuracy of the TSPI.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Kalman Filter, Range Difference of Arrival (RDOA), Time Difference of Arrival (TDOA), Frequency Difference of Arrival (FDOA)

SHIPBOARD WIRELESS NETWORK APPLICATIONS
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Recently, the need to leverage technologies for better utilizing valuable personnel resources has become more important. Wireless Local Area Networks (WLANs) have been shown to be an enabling technology that allows companies in commercial industry to become more productive. Research has been conducted at the Naval Postgraduate School to determine how this technology can be utilized to help the Navy perform shipboard operations more efficiently.

Continuing the work of previous theses at NPS, the objective of this thesis is threefold. First, WLAN standards are examined. Second, laboratory tests are conducted to determine the performance of WLANs in which access points are configured as radio repeaters. Finally, a web-based application is developed for shipboard gage calibrations. The application automates major portion of gage calibration process by allowing technicians to submit and to view the calibration results using a web browser through wired or wireless LANs.

Testing results show that the access points from certain vendors are able to operate as radio repeaters and still provide adequate performance. Repeater functionality is not specified in IEEE 801.11 standards, and its implementation is vendor specific. Demonstration of the web-based gage calibration application shows that it is effective in improving calibration efficiency.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: IEEE 802.11, Wireless Local Area Network, Active Server Pages, Internet Database

AN EXAMINATION OF POSSIBLE ATTACKS ON CISCO'S IPSEC-BASED VPN GATEWAYS

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Virtual Private Networks (VPNs) are an emerging security solution for computer networks in both the government and corporate arena. IPSec, the current standard for VPNs, offers a robust, standards-based, and cryptographically effective solution for VPN implementation. Because of the immense complexity of IPSec, effective analysis is difficult. In an environment where Information Warfare in general, and computer network attack in particular are becoming more pervasive, it is necessary conduct a critical, independent evaluation of IPSec from a security perspective.

In order to develop an effective evaluation of IPSec VPNs, a Cisco Systems IPSec-based VPN router network is used as an example. A detailed analysis of Cisco's IPSec-based implementation, as well as of the IPSec standard itself is conducted to determine what, if any, attacks or vulnerabilities exist in each.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control and Communications, Electronics, Electronic Warfare

KEYWORDS: Virtual Private Networks (VPN), Internet Protocol Security (IPSec), Computer Network Attack, Computer Security, Computing and Software, Network Security, Encapsulating Security Payload (ESP), Authentication Header (AH), Routers, Information Warfare (IW)

LOCALIZATION OF WIRELESS COMMUNICATION EMITTERS USING TIME DIFFERENCE OF ARRIVAL (TDOA) METHODS IN NOISY CHANNELS

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The ability to provide position information of wireless emitters comprises a very important communication tool and has extremely valuable applications to military as well as civilian life. GSM is the most popular method of modulation adopted around the world, for mobile telephony. This thesis is focused on the Time Difference Of Arrival (TDOA) estimation, applied to GSM signals, in noisy channels. Improvements in denoising, in conjunction with wavelet processing, are proposed for estimating the TDOA of signals received at two spatially separated sensors. Wavelet denoising based on a modified maximum likelihood method and a higher order moment method is proposed, to improve the performance. A numerical evaluation of the methods, when unequal SNR conditions prevail, is presented. The performance of the proposed denoising methods in a jamming environment is also addressed. Simple excision schemes to improve the performance when jamming is present, are evaluated. Simulation results indicate good performance of the methods and improved estimates relative to the ones obtained using no denoising. Jamming presence degrades the performance but still the extracted estimates are improved.

DoD KEY TECHNOLOGY AREAS: Electronics, Electronic Warfare

KEYWORDS: Global System for Mobile (GSM),Time Difference Of Arrival (TDOA), Wavelet Denoising, Jamming, Emitters Localization

PREDICTION OF WIRELESS COMMUNICATION SYSTEMS PERFORMANCE IN SHIPBOARD COMPARTMENTS IN THE 2.4 GHz ISM BAND

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A physical understanding and consequent mathematical modeling of RF energy in naval indoor environments is of vital importance to the usability and effectiveness of communication systems used by the Navy. Over the last few years, there is a growing interest in placing Wireless Local Area Networks (WLANs) in ships and submarines. Especially large ships yet to be constructed, are designed with increased electronic systems but limited personnel. Reliable electronic systems will be crucial for efficient ship operation and survivability.

This thesis investigates the feasibility of deploying a physical model called Numerical Electromagnetic Code-Basic Scattering Code (NEC-BSC) to simulate confined naval compartments in the 2.4 GHz Industrial Scientific Medical (ISM) band. More specifically, using NEC-BSC the coverage area, the number and positions of transmitters and observation points and the statistics of Radio Frequency (RF) signal distribution were described. The area specifically targeted for this research was a typical two-story missile room. Additionally, some important conclusions regarding the validity of NEC-BSC for indoor applications are presented and some recommendations for future research are provided.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Simulation of Signal Propagation, Indoor Radio Propagation, Typical Missile Room, NEC-BSC

QUALITY OF SERVICE ANALYSIS IN MOBILE AD-HOC NETWORKS

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This thesis proposes schemes to provide Quality of Service (QoS) in mobile ad-hoc networks (MANETs). To achieve QoS, independently of the routing protocol, each mobile node participating in the network must implement traffic conditioning, traffic marking and buffer management (Random Early Drop with in-out dropping) or queue scheduling (Priority Queuing) schemes. In MANETs, since the mobile nodes can have simultaneous multiple roles (ingress, interior and destination), it was found that traffic conditioning and marking must be implemented in all mobile nodes acting as source (ingress) nodes. Buffer management and queue scheduling schemes must be performed by all mobile nodes.

By utilizing the Network Simulator (NS2) tool, this thesis focused on the empirical performance evaluation of the QoS schemes for different types of traffic (FTP/TCP, CBR/UDP and VBR/UDP), geographical areas of different sizes and various mobility levels. Key metrics, such as throughput, end-to-end delay and packet loss rates, were used to measure the relative improvements of QoS-enabled traffic sessions. The results indicate that in the presence of congestion, service differentiation can be achieved under different scenarios and for different types of traffic, whenever a physical connection between two nodes is realizable.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MANET, JTRS, NS2, DSR, QoS, RSVP, Diffserv

EFFECTIVENESS OF MODELING A HIGH POWER RADIO FREQUENCY (HPRF) WEAPON SYSTEM (U)

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The objective of this research was to model the electromagnetic output of a proposed High Power Radio Frequency (HPRF) weapon system. The antenna data was generated using GNEC, a method of moments computational electromagnetic code. The impulsive excitation and resultant transient near-fields were modeled using electrical circuit analysis and inverse Fast Fourier Transformation programmed in MATLAB 5.3. The peak amplitudes and waveforms were the primary focus of this study

DoD KEY TECHNOLOGY AREAS: Electronics Warfare, Directed Energy Weapons, Modeling and Simulation

KEYWORDS: Electronic Warfare, Directed Energy Weapons, Antenna Design, Antenna Modeling, Electromagnetic Simulation

THE DESIGN, SIMULATION, AND FABRICATION OF A BICMOS VLSI DIGITALLY PROGRAMMABLE GIC FILTER

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This thesis used a previously designed programmable GIC filter as a basis in which to incorporate a BiCMOS operational amplifier. An NPN bipolar transistor layout was designed and incorporated into an opamp layout, which was a modified version of a CMOS-only design. The BiCMOS opamp was simulated using Silvaco SmartSpice and showed considerable improvement over its CMOS equivalent. Additional improvements were made to the GIC filter to include a passgate with reduced resistance, and a correction was made to the capacitor layout. Simulations were also performed on a switched-capacitor bilinear resistor and a switched-capacitor variable bilinear resistor. Results from the bilinear resistor simulations require further study and testing. Finally, a VLSI layout of the filter was accomplished using LASI and has been submitted to MOSIS for fabrication.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: GIC Filter, Silvaco SmartSpice

VULNERABILITIES OF MULTIPROTOCOL LABEL SWITCHING

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This thesis examines performance and security aspects of Multiprotocol Label Switching (MPLS). Specifically, behavior of the Resource Reservation Protocol for Traffic Engineering (RSVP-TE) and its use as a Label Distribution Protocol (LDP) is observed. Hypothetical vulnerabilities are developed through analysis of the protocols and tested using a simple network topology. Testing results and areas for future work are presented.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Computer Networks, Multiprotocol Label Switching, MPLS, Vulnerabilities, Exploits

EXPLOITATION OF AN IEEE 802.11 STANDARD WIRELESS LOCAL AREA NETWORK THROUGH THE MEDIUM ACCESS CONTROL (MAC) LAYER

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Wireless Local Area Networks (WLAN) have increased in popularity and use in recent years and with this has come a respective increase in interest in ways to exploit these networks. Among the varying proprietary and standardized implementations available, the IEEE 802.11 standard WLAN has become the predominant implementation of WLAN in use today. This thesis examines the Medium Access Control (MAC) layer of the IEEE 802.11 WLAN for security weaknesses and vulnerabilities that can be exploited to eavesdrop, modify or inject data, or gain access to a WLAN. The functionality of the MAC layer in the IEEE 802.11 standard is reviewed and specific known attacks against it are presented and analyzed. Finally, a review of a current proposal to enhance the security of the IEEE 802.11 standard is presented.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Other (Information Operations)

KEYWORDS: Wireless Local Area Networks, IEEE 802.11, Exploitation, Medium Access Control Layer, Cryptology, Network Security, Information Operations

COMBINED ADAPTIVE POWER-RATE CONTROL IN CDMA SYSTEMS

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In this thesis, combined power and rate adaptations in the reverse channel of a multicell CDMA cellular system over a Nakagami-Lognormal frequency selective fading channel are considered. Imperfect power control, user traffic distribution, Intracell interference, co-channel interference, a RAKE receiver and spatial diversity are also considered. Numerical results obtained by Monte Carlo simulation show that power and rate adaptations result in an increase of the system capacity and prolong the mobile station's battery life.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: CDMA Systems, Battery Life

DIGITAL LOW PROBABILITY OF INTERCEPT RADAR DETECTOR

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The function of a Low Probability of Intercept (LPI) radar is to prevent its interception by an Electronic Support (ES) receiver. This objective is generally achieved through the use of a radar waveform that is mismatched to those waveforms for which an ES receiver is tuned. This allows the radar to achieve a processing gain, with respect to the ES receiver, that is equal to the time-bandwidth product of the radar waveform. This processing gain allows the LPI radar to overcome the range-squared advantage of the ES receiver in conventional situations. Consequently, a conventional ES receiver can only detect an LPI radar at very short ranges (<3 nm).

The focus of this thesis was to develop an ES receiver to detect LPI radar signals with the same sensitivity as conventional pulse signals. It implements a detector which employs a technique, known as "deramping," that forms an adaptive matched filter to the linear FMCW LPI radar signal in order to achieve the processing gain that is equal to the received signal's time-bandwidth product. An experimental transmitter was built to emulate the radar signal with FMCW characteristics and transmitted through a standard gain horn. The transmitted signal is then received via a receiver horn, mixed down to an intermediate frequency (IF), sampled by an A/D convertor and digitally deramped using a Pentium II computer.

It was demonstrated that the LPI radar signal can be extracted from the noise background by means of digital deramping.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: FMCW, LPI, LPI Radar, Deramp, PILOT, Chirp, Frequency-modulated Continuous Wave

CAPABILITIES AND LIMITATIONS OF ORTHOGONAL FREQUENCY-DIVISION MULTIPLEXING IN WIRELESS APPLICATIONS

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Orthogonal frequency-division multiplexing (OFDM) is a transmission scheme that, unlike conventional transmission schemes that send only one signal at a time over one radio frequency, sends a high-speed signal concurrently on a number of different frequencies. This allows for a robust and efficient use of bandwidth. These characteristics make OFDM particularly suitable for wireless local area network communications that are susceptible to noise, interference and distortion. In this paper, concepts are introduced along with their applications to high speed data transmission. In addition, a technique to exploit OFDM systems, based on exploitation techniques for direct sequence spread spectrum systems, is developed.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Wireless Applications, High-Speed Signal

ANGULAR RATE ESTIMATION FOR MULTI-BODY SPACECRAFT ATTITUDE CONTROL
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Spacecraft with high performance attitude control systems requirements have traditionally relied on imperfect mechanical gyroscopes for primary attitude determination. Gyro bias errors are connected with a Kalman filter algorithm that uses updates from precise attitude sensors like star trackers. Gyroscopes, however, have a tendency to degrade or fail on orbit, becoming a life-limiting factor for many satellites. When errors become erratic, pointing accuracy may be lost during short star gaps. Unpredictable gyros degradations have impacted NASA spacecraft missions such as Skylab and Hubble Space Telescope as several DoD and ESA satellites. An alternative source of angular rate information is a software implemented real tie dynamic model. Inputs to the model from internal sensors and known spacecraft parameters enable the tracking of total systemangular momentum from which body rates can be determined. With this technique, the Kalman filter algorithm provides error corrections to the dynamic model. The accuracy of internal sensor and input parameters determine the effectivenes of this angular rate estimation technique. This thesis presents the background for understanding and implementation of the technique into a representative attitude determination system. The system is incorporated into an attitude simulation model developed in SIMULINK to evaluate the effects of dynamic modeling errors and sensor inaccuracies. Results are presented that indicate that real time dynamic modeling is an effective method of angular rate determination for maneuvering multi-body spacecraft attitude control systems.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Modeling and Simulation

KEYWORDS: Dynamic Gyro, Kalman Filter, Attitude Determination, Rate Estimation, Star Trackers, Attitude Simulation, Multi-body Dynamics, Quaternion, MATLAB, SIMULINK

PERFORMANCE ANALYSIS OF PILOT-AIDED FORWARD CDMA CELLULAR CHANNEL
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Jan E. Tighe, Department of Electrical and Computer Engineering
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In this thesis the performance of the forward channel of a DS-CDMA cellular system operating in a Rayleigh-fading, Lognormal-shadowing environment is analyzed. An upper bound on the probability of bit error, including all the participating interference is developed. In addition, various techniques such as sectoring and forward error correction in the terms of convolutional encoding are applied to optimize the performance. The performance is further improved by applying a narrow bandpass filter in the pilot tone branch of the demodulator. The bandwidth of the filter is then adjusted in the means of the interference power passing through and observe the effects on the probability of bit error of the system. Moreover, pilot tone power control is added to enhance the demodulation. Finally, in this thesis a simple single cell system functioning as a port-to-port network communication between very small numbers of users is analyzed.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: DS-CDMS Cellular System, CDMS Cellular Channel

ANALYSIS AND EVALUATION OF THE ELECTROMAGNETIC COMPATIBILITY OF COTS WIRELESS LAN COMPONENTS ONBOARD SUBMARINES

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Wireless Local Area Networks (WLANs) have become increasingly popular in recent years both in the civilian and military sectors. A series of theses have been produced at the Naval Postgraduate School to provide a Commercial-Off-The-Shelf (COTS) component WLAN system for the New Attack Submarine (NSSN) Program. However, the environment of a submarine is a comp licated, electromagnetically noisy place. The Electromagnetic Compatibility (EMC) standards regulating electromagnetic emissions and electromagnetic susceptibility differ greatly between the civilian and the military sectors. Any electromagnetic incompatibility between systems can be disruptive to their operation. A great deal of EMC analysis must be accomplished in order to introduce components from one regulatory world into another.

The goal of this thesis is to verify that the Aironet 4800 DS WLAN component suite meets the military regulatory standard with regard to electromagnetic compatibility for submarine systems. This verification was accomplished by first analyzing Federal Communication Commission EMC reports on the 4800 series components. The 4800 series then underwent several EMC tests mandated by the military standard governing EMC, MIL-STD-461E. CE102 and RE102 tests were conducted at the Naval Postgraduate School in Monterey, CA. CS101 and RS103 tests were conducted at the EMC laboratories of Electric Boat in Groton, CT. Each test is representative of one aspect of the EMC environment. Based on this limited testing of conducted emissions, radiated emissions, conducted susceptibility and radiated susceptibility, it appears that these commercial components meet the MIL-STD-461E standard with respect to submarines.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications

KEYWORDS: Wireless LAN, WLAN, Aironet 4800 DS WLAN, NSSN Program

SENSITIVITY ANALYSIS OF AN OPTIMUM MULTI-COMPONENT AIRBORNE ELECTRONIC ATTACK CONFIGURATION FOR SUPPRESSION OF ENEMY AIR DEFENSE

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In response to the need to augment or replace the aging EA-6B Prowler, Integrated Product Teams (IPTs) are formed to conduct an Analysis of Alternatives (AoA) to define the operation requirements that address the Department of Defense's (DoD) Airborne Electronic Attack (AEA) need. This thesis is primarily concerned with determining an optimum multi-component command and control warfare/electronic attack (C2W/EA) configuration of assets including platform, jammer and receiver selection for the suppression of enemy air defense (SEAD). A sensitivity analysis of the solution evolved by simulation is performed in order to determine the robustness in the derived measures of effectiveness to system failures or variances in the performance parameters. The tasks involved with this effort include simulating the classified RT-4 distributed scenarios to baseline the corresponding measure of effectiveness (i.e., target engagement time by surface-to-air missile site). One or more parameters in the scenario solution are then changed (receiver

dynamic range, jamming assignment, etc.) and the measures of effectiveness are rederived in order to investigate their sensitivity to these changes. In addition, this thesis develops a User's Guide for the Naval Research Laboratory (NRL) Advanced Reactive Electronic Warfare Simulation (ARES) software, Version 1.12, used in the analysis.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Electronic Warfare, Sensors, Modeling and Simulation

KEYWORDS: Analysis of Alternatives, Airborne Electronic Attack, EA-6B, Suppression of Enemy Air Defense

SIMULATION OF AN ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING BASED UNDERWATER COMMUNICATION SYSTEM USING A PHYSICS BASED MODEL FOR THE UNDERWATER ACOUSTIC SOUND CHANNEL

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The primary thrust of this thesis is the development of a computer-based simulation of an Orthogonal Frequency Division Multipexing (OFDM) based underwater acoustic communication system. The product will support the testing and evaluation of various digital signal processing algorithms applicable to underwater acoustic communication systems using OFDM as well as the study of the effects of the acoustic channel and communication system factors on the key parameters of the system such as bit error rate, received signal to noise ratio, frequency band of employment and overall system bit rate. The underwater acoustic sound channel is modeled using a physics based parabolic equation approximation. The simulation models the key components in the transmitter and receiver that contribute to the overall performance of the system. The results of the thesis provide expected values for system performance in terms of bit rate, bit error rate and received SNR for given frequency bands and are validated through comparison to theoretically derived expectations and to ocean testing of OFDM underwater communication systems.

DoD KEY TECHNOLOGY AREAS: Electronics, Other (Underwater Acoustics)

KEYWORDS: Digital Signal Processing, Underwater Acoustic Communication System

EFFECTIVENESS OF THE EA-6B AIRCRAFT STAND-OFF JAMMING AGAINST THREAT AND EARLY WARNING RADAR DURING OPERATION ALLIED FORCE IN SERBIA, AND OPERATIONS NORTHERN AND SOUTHERN WATCH IN IRAQ

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This thesis addresses the jamming effectiveness of electronic attack (EA) operations of the EA-6B against early warning (EW) and threat radar during Operation ALLIED FORCE (OAF) from March-June 1999 and Operations NORTHERN WATCH (ONW) and SOUTHERN WATCH (OSW) from July-August 2000. Effectiveness was determined by examining confirmation from all-source intelligence regarding events where jamming was used against targeted radar to degrade their detectability or tracking of strike aircraft. In the absence of confirmation data, the EA-targeting effectiveness was resolved by modeling individual EA-targeting incidents and analyzing whether striker aircraft were protected from enemy radar. In-depth analysis of EA-6B incidents were selected based on the post-mission reports from the EA-6B, strike

aircraft, and other reconnaissance and surveillance sources. For OAF, ONW, and OSW, 20 EA-6B incidents were modeled for in-depth analysis. The limited sample size and the inability to always correlate all-source intelligence to an event timeframe impacted the results. The Improved Many-on-Many (IMOM) model was used to model the radar and Tactical Jamming System. The conclusions were based on the post-incident mission analysis, all-source intelligence correlation to an incident recreation, and the theoretical calculation of expected jamming effectiveness against radar systems.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: EA-6B, AN/ALQ-99, Tactical Jamming System, Air War Over Serbia (AWOS), Operation ALLIED FORCE (OAF), Operation NORTHERN WATCH (ONW), Operation SOUTHERN WATCH (OSW), Serbia, Iraq, Electronic Attack, Targeting

EXPERIMENTAL USE OF THE LAWRENCE LIVERMORE DEVELOPED MICRO-POWER SHORT PULSE RADAR TO EXTRACT LOW AMPLITUDE MODULATION SIGNALS CORRESPONDING TO HUMAN HEART RATES

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Detecting a living person buried in rubble or concealed in buildings has far reaching search and rescue as well as military applications. This thesis developed a filter from a catalog of close range impulse response signals that were acquired using Micro-power Short Pulse Radar developed at Lawrence Livermore National Laboratory.

Utilizing matched filtering techniques, low amplitude modulations signals corresponding to the human heart were extracted from return signals out to 40 feet. Human heart signals were extracted from return signals in air and through different materials. The matched filter output of the signal compared with the noise was then used to develop detection probabilities and performance characteristics based on range and material.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Close Range Impulse Response Signals, Micro-Power Short Pulse Radar, Human Heart Signals

MODELING THE EFFECTS OF GPS JAMMING ON A THEATER CAMPAIGN

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This study reviews the manner in which four precision-guided weapons utilize the NAVSTAR Global Positioning System (GPS) to increase their accuracy, and threats to GPS that may be employed to reduce their accuracy. The study incorporates a Navy-approved Modeling and Simulation (M&S) program to modify weapons parameters affected by GPS. The M&S system is used to simulate a large-scale theater campaign, based upon actual war plans. The results of the simulation scenario are used to evaluate possible threats to GPS guided weapons and to highlight thought processes that military planners may need to consider when operating in a GPS-denied or GPS-degraded electronic warfare environment.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Electronic Warfare

KEYWORDS: NAVSTAR GPS, GPS Jamming, Weapons Parameters

SPACE TRAINING AND EDUCATION FOR USN CRYPTOLOGIC OFFICERS - THE ROAD TO SPACE CERTIFICATION

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This thesis discusses the importance of space-related education and training for Naval cryptologic officers in their efforts to support the warfighter. It includes a discussion of the learning continuum concept, an outline of cryptologic officer's career milestones for space-related training, and a discussion of the Navy's Distributed Learning initiatives. This thesis provides a framework for the establishment of a Space Certification Program for Naval cryptologists. The proposed Space Certification model was designed to allow expansion of the program to include Naval officers in other communities.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Space Training and Education, Cryptologic Officers, Distributed Learning Initiatives

VULNERABILITY ASSESSMENT OF WIRELESS DATA NETWORK SIGNAL TRANSMISSIONS

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The abstract is for official use only.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Wireless LAN, Wireless Bridge, IEEE 802.11, IEEE 802.16

DEFINING AND VALIDATING A COVERT ANALYSIS DETECTION (CAD) SYSTEM AND ITS STEALTHY DATA CAPTURE, CONTROL AND ANALYSIS CAPABILITIES

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A Covert Analysis Detection (CAD) system is an operationalized honeypot or honeynet that is designed to covertly capture, control and provide analysis capabilities of all traffic that flows through it. It was found that the covert data capture capability not only revealed the attackers tools (captured as source code) and tactics (collection of compromised systems), but also over time it revealed that that attacker's actual motive was the creation of a distributed denial of service (DDoS) network. The discovery of this lethal network

tool and all the signatures of its creation and maintenance, proved the validity of the CAD's capabilities to aid in the enhancement of our information protection resources.

DoD KEY TECHNOLOGY AREA: Command, Control and Communications, Computing and Software

KEYWORDS: Network Security, Information Protection, Intrusion Detection, Deception, Deterrence, Honeypot, Honeynet, Distributed denial of service (DDoS)

DESIGN AND PERFORMANCE ANALYSIS OF AN ASYNCHRONOUS PIPELINED MULTIPLIER WITH COMPARISON TO SYNCHRONOUS IMPLEMENTATION

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Synchronous techniques have dominated digital logic system design for decades because they are well understood and less complicated to implement. With the advent of more exotic high-speed transistors, the issues of clock skew, system performance, power consumption, and technology migration become critical to synchronous system designers. Asynchronous digital design techniques utilize a local completion signal or request/acknowledge handshake to lend the stability afforded by the global clock in synchronous systems. This research evaluates a moderately complex digital system, an 8x8-bit multiplier utilizing high speed Indium Phosphide heterostructure bipolar junction transistors, to determine whether asynchronous logic design can compete with synchronous design in terms of system speed and power consumption. Theoretical timing equations are developed that relate the relative merits of each technique for input-to-output latency and system throughput. Tanner SPICE simulation tools are used to evaluate the full 8x8-bit asynchronous array multiplier. Finally, direct comparisons are made between five separate pipelined configurations of the multiplier utilizing both synchronous and asynchronous timing methodologies. As integrated circuits become smaller, faster, and more complex, asynchronous schemes will continue to mature and become more prevalent in digital system design.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Asynchronous Logic, Pipelined Logic, Micropipelines

WEB-BASED TEACHING AND LEARNING OF ELECTRICAL ENGINEERING COURSES

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Second Reader: Herschel H. Loomis, Department of Electrical and Computer Engineering

This thesis describes the design of an interactive Web-based course, namely EC4810 Fault Tolerant Computing, taught in the Department of Electrical and Computer Engineering (ECE), at the Naval Postgraduate School. It is part of the ECE Department's Distributed Learning program in which students will use multimedia enhanced online courses through the Web. A major accomplishment of this thesis is the development of a template for other courses. A step-by-step guide has been developed that outlines the process of online course maintenance and procedures for producing other courses.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Web-Based Learning, Multimedia, On-Line Course

DEVELOPMENT, SIMULATION AND EVALUATION OF THE IEEE 802.11a PHYSICAL LAYER IN A MULTIPATH ENVIRONMENT

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This thesis describes the development of a simulation of the newly proposed IEEE 802.11a physical layer and demonstrates the effects of Additive White Gaussian Noise (AWGN) and multipath on its performances. The IEEE 802.11a standardization group has selected Orthogonal Frequency Division Multiplexing (OFDM) as the basis for the new 5 GHz standard, targeting a range of data rates from 6 up to 54 Mbps.

Coded OFDM (COFDM) is a channel coding and modulation scheme which mitigates the adverse effects of fading by using wideband multicarrier modulation combined with time interleaving and a convolutional error correcting code. A guard interval is inserted at the transition between successive symbols to absorb the intersymbol interference created by the time domain spread of the mobile radio channel. The decoding process is performed using differential demodulation in conjunction with a hard decision Viterbi decoder.

The simulation results showed that COFDM system is capable of indoor environment communications in the presence of known multipath and noise conditions. The results obtained also showed that the COFDM configuration is immune to Doppler shift of 5 to 15 Hz.

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DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Coded Orthogonal Frequency Division Multiplexing (COFDM), MATLAB, Convolutional Encoding, Viterbi Decoder, Interleaver, Multipath, Additive White Gaussian Noise (AWGN), Inverse Fast Fourier Transform (IFFT), Guard Interval

SIMULATION AND PERFORMANCE ANALYSIS OF THE AD HOC ON-DEMAND DISTANCE VECTOR ROUTING PROTOCOL FOR TACTICAL MOBILE AD HOC NETWORKS

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This thesis presents a simulation and analysis of the Ad Hoc On-Demand Distance Vector Routing Protocol (AODV) for mobile ad hoc network (MANET) environments using the Network Simulator 2 (NS2) tool. AODV is being suggested for possible implementation in the Joint Tactical Radio System (JTRS) for the United States military. Utilizing an AODV model resident in NS2, the simulation focuses on key performance parameters that include the packet delivery fraction, routing loss, buffer loss, total loss, throughput and goodput. The AODV node movement and traffic connection files have been generated to measure the network performance for a given environment using specific parameters. The results reported in this thesis indicate that the network environment size, packet rate and offered load are critical to the network performance. Node velocity played a minimal role in affecting the overall network performance.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communication, Computing and Software, Modeling and Simulation

KEYWORDS: Joint Tactical Radio System, Mobile Ad Hoc Network, Network Simulator 2, Protocol Analysis, Ad Hoc On-Demand Distance Vector Routing

A 3D PARABOLIC EQUATION (PE) BASED TECHNIQUE FOR PREDICTING PROPAGATION PATH LOSS IN AN URBAN AREA

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Tri Ha, Department of Electrical and Computer Engineering

A mobile radio environment places fundamental limitations on the performance of wireless communication systems. Most models developed to predict propagation path loss have been historically performed in a statistical approach. These models are expensive to develop and do not offer the accuracy, computational advantages, and sufficiency as the parabolic equation (PE). The goal of this thesis is to develop a 3D model based on PE for predicting propagation path loss in urban areas on flat and hilly terrains. The PE method offers the computational advantages, where one can approximate the elliptic operator governing the true wave behavior by a much simpler parabolic operator that permits marching in range. Moreover those all-important aspects of propagation such as reflection and diffraction are included automatically in the formulation. Four test problems on flat terrain and two test problems on hilly terrain will be simulated. For the flat terrain, the 3D PE model results will be compared with the two-ray, the four-ray, the UTD, and the numerical integration technique results. For the hilly terrain, the results of the 3D PE model will be compared with the UTD and the numerical integration technique results.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Electronic Warfare

KEYWORDS: Wireless Communication Systems, Propagation Path Loss

MODELING AND ANALYSIS OF CELLULAR CDMA FORWARD CHANNEL

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Master of Science in Applied Mathematics-March 2001
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In this thesis, the forward channel model for a DS-CDMA cellular system operating in a slow-flat Rayleigh fading and lognormal shadowing environment is developed, which incorporates the extended Hata model to predict median path loss. Forward error correction is integrated into the model by applying convolution encoding with soft-decision decoding. The worst-case probability of bit error for a mobile user at the edge of the center cell of a seven-cell cluster is developed using Gaussian approximation. In estimating the probability of bit error, a statistical model is developed which approximates the sum of d multiplicative chi-square (two degrees of freedom)-lognormal random variables as a multiplicative chi-square (with 2d degrees of freedom)-lognormal random variable. Using this approximation, the performance of the cellular system is examined under a range of shadowing conditions, for various user capacities and with antenna sectoring as they compare with Monte Carlo simulated results. Next, our worst-case performance analysis is modified to accommodate users that are distributed in the cell according to a specified distribution and compare results with the worst-case performance. Finally, a fast power control is introduced into the forward channel and explore system performance with power control under a range of operating conditions as it compares with the fixed-power performance.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: CDMA, Wireless, Performance Analysis, Rayleigh Fading, Lognormal Shadowing, Walsh Functions, Hata Model, Convolutional Codes, User Distribution, Power Control, Sum Distribution, Gaussian Approximation, Forward Channel Model, Antenna Sectoring

MODELING AND PERFORMANCE ANALYSIS OF CELLULAR CDMA CHANNEL WITH RAKE RECEIVER

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Jan E. Tighe, Department of Electrical and Computer Engineering

In this thesis, a cellular CDMA reverse channel model was established which incorporates a time-invariant discrete multipath Nakagami-fading channel in a multiple-cell system. The effects of intra and inter-cell interference, perfect power control, lognormal shadowing and RAKE receiver with varying number of taps are investigated. For performance improvement forward error correction and smart antenna techniques are incorporated into the model. Expressions for probability of bit error are developed under a range of operating conditions and the model is tested using Monte Carlo Simulation.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: CDMA Reverse Channel Model, RAKE Receiver

ANALYSIS OF INTEL IA-64 PROCESSOR SUPPORT FOR SECURE SYSTEMS

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Current architectures typically focus on the software-based protection mechanisms rather than hardware for providing protection. In fact, hardware security mechanisms can be critical for the construction of a secure system. If hardware security mechanisms are properly utilized in a system, security policy enforcement can be simplified. Systems could be constructed for which serious security threats would be eliminated.
This thesis explores the Intel IA-64 processor's hardware support and its relationship to software for building a secure system. To analyze the support provided by the architecture, hardware protection mechanisms were examined. This analysis focused on the following mechanisms: privilege levels, access rights, region identifiers and protection key registers. Since protection checks are made through the translation lookaside buffer (TLB) during the virtual-to-physical translations, the TLB structure was an area of focus throughout the research for this thesis.
Proper use of the TLB-based hardware protection features permits protection in the IA-64 architecture. It enables the processor hardware and the operating system to collaborate to enforce security policies efficiently.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Protection, Intel IA-64 architecture, Secure Systems

BANDWIDTH REQUIREMENTS FOR THE ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) COMMAND VARIANT

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The goal of this thesis is to identify the bandwidth requirements for the command variant of the Advanced Amphibious Assault Vehicle (AAAV). The work focuses on the network established to support an infantry

battalion COC. At the center of this network will be the AAAV(C). All higher and subordinate communications links that connect directly with the AAAV(C) are modeled. The intent is to identify all traffic received and transmitted through the AAAV(C). Current systems are not discussed, as this study is intended to be independent of current system characteristics. The model is based on Internet Protocols (IP), with all communications, including voice and video, routed via IP addresses. This model attempts to provide better fidelity for future requirements analysis. Data on message size and transmission interval are identified that will allow grouping and analysis of message sets for future systems. Doctrinal messages appropriate for each node (unit) are identified and each message is then assigned a size (bits), and a transmission interval (minutes). Using a maneuver ashore scenario, network traffic flows for a 24-hour period are modeled with the software simulation tool Extend(tm). The model is then optimized and the minimum bandwidth required to support the scenario is identified.

DoD KEY TECHNOLOGY AREAS: Electronics, Command, Control and Communications

KEYWORDS: Advanced Amphibious Assault Vehicles, AAAV, Communications

DESIGN AND IMPLEMENTATION OF A HIGH-POWER RESONANT DC-DC CONVERTER MODULE FOR A REDUCED-SCALE PROTOTYPE INTEGRATED POWER SYSTEM

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An Integrated Power System (IPS) with a DC Zonal Electrical Distribution System (DCZEDS) is a strong candidate for the next generation submarine and surface ship. To study the implementation of an IPS with DCZEDS, members of the Energy Sources Analysis Consortium (ESAC) are currently constructing a reduced-scale laboratory. One fundamental component of DCZEDS is the Ships Service Converter Module (SSCM), commonly known as a buck DC-DC converter. This thesis documents the design, simulation, construction and testing of a 500V/400V, 8kW resonant soft-switched DC-DC converter. In theory, resonant converters will operate more efficiently and generate less Electromagnetic Interference (EMI) when compared to a standard hard-switched converter. In this thesis, the resonant converter is tested and compared to a hard-switched DC-DC converter that was designed for ESAC's reduced-scaled IPS. The results verify that the resonant DC-DC converter realizes significant efficiency and EMI generation improvements over the hard-switched converter at the cost of a more complex control system and power section.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicle-Ship and Watercraft, Electronics

KEYWORDS: Integrated Power System, Ships Service Converter Module, DC-DC Converter, DC Zonal Electrical Distribution System, DCZEDS

DETECTION AND FEATURE EXTRACTION OF MINE-LIKE OBJECTS FROM SEISMIC SONAR SIGNALS

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This thesis investigates detection and classification issues when dealing with seismic signals and represents a first step in the direction of automated detection and classification of mine-like signals obtained using a seismic approach. A computationally cheap detection scheme that utilizes a combination of a simple

combination of a short-term energy and zero-crossing detector is implemented and tested on five different classes of targets, resulting in a 100% detection rate for all non-natural targets and 33% detection rate of mine sized rock buried in sand.

Three feature extraction methods are evaluated for their possible use in a Gaussian Mixture Model classifier: higher order moments, pole extraction from impulse response modeling using the Steiglitz-McBride iteration, and Radial Basis Function Modeling of data. These methods demonstrate promising results for use in a classifier. However, only a very limited number of data trials per class was available in this work, and the proposed set-up needs to be further validated with additional data.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Mine Warfare)

KEYWORDS: Buried Mine Detection, Buried Mine Feature Extraction, Mine Warfare, Seismic Sonar, Mine Classification

CONCEPTS, APPLICATIONS AND ANALYSIS OF A SUBMARINE BASED WIRELESS NETWORK

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As information technology tools continue to improve, we must take advantage of this wave by developing wise solutions to help automate many daily tasks presented onboard submarines. Java based applications and Commercial-off-the-Shelf (COTS) technology provides us low cost solutions that increase the availability and mobility of the information we seek. Small pen based computers and wireless LANS allow us to create dynamic and distributable applications that can route paperwork or fight casualties. It is imperative we take full advantage of these technologies in the design of our new submarines as well as in retrofit of our older ones.

This thesis attempts to solve a key task, Damage Control (DC) communications, by designing a Java based application known as SWIPNet (Submarine Wireless Prototyped Network). This virtual grease board application uses multicast sockets to send standard DC and crew reports to all wireless handhelds that participate in a casualty. A proposed Virginia class wireless network, known as the Non Tactical Data Processing System (NTDPS), was then analyzed to determine network efficiency in the presence of SWIPNet and 14 other submarine type network loads. Demonstrations have proven that SWIPNet provides a more efficient way to communicate and can function effectively on the NTDPS.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Computing and Software, Command, Control and Communications

KEYWORDS: Wireless Local Area Network, Mobile Computing, Java, Pen-Based Computing, Pdas, Handheld Computers, Database, OPNET Modeler, Microsoft Access, Damage Control, Multicast Sockets, Wireless Communications

ANALYSIS OF TRACKING AND IDENTIFICATION CHARACTERISTICS OF DIVERSE SYSTEMS AND DATA SOURCES FOR SENSOR FUSION

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In the Command and Control mission, new technologies such as 'sensor fusion' are designed to help reduce operator workload and increase situational awareness. This thesis explored the tracking characteristics of

diverse sensors and sources of data and their contributions to a fused tactical picture. The fundamental building blocks of any sensor fusion algorithm are the tracking algorithms associated with each of the sensors on the sensor platform. In support of this study, the MATLAB program 'fusim' was written to provide acquisition managers a tool for evaluating tracking and sensor fusion algorithms.

The fusim program gives the user flexibility in selecting: sensor platforms, up to four sensors associated with that platform, the target types, the problem orientation, and the tracking algorithms to be used with the sensors. The fusim program was used to compare tracking algorithms in a multiple sensor/multiple target environment. Specifically, the Probabilistic Data Association Filter, the Interacting Multiple Models Filter, the Kalman Filter and the Constant Gain Kalman Filter were evaluated against multiple maneuvering, non-maneuvering, and fixed targets. It is recommended that this study be continued to evaluate advanced tracking and data association techniques, to expand the program to allow attribute tracking and identification, and to study the Human-Machine Interface aspects of sensor fusion.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Sensors, Command Control and Communications, Computing and Software

KEYWORDS: Data Fusion, Sensor Fusion, Tracking, Tracking Algorithms, Kalman Filter, Probabilistic Data Association, PDA, Interacting Multiple Models, IMM, Simulation

USING COMMERCIAL OFF-THE-SHELF DIGITAL SIGNAL PROCESSORS FOR RELIABLE SPACE BASED DIGITAL SIGNAL PROCESSING

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A radiation tolerant testbed was designed using a Commercial-off-the-Shelf (COTS) Digital Signal Processor (DSP) and presented to prove the concept of Triple Modular Redundant (TMR) processors in order to make a COTS DSP radiation tolerant design. The system was designed to handle the effects of radiation associated with Single Event Upset only.

Two of the industry's leading programmable 32-bit floating-point digital signal processors were reviewed for this thesis, Analog Devices ADSP-21060 and the Texas Instruments TMS320C6701. The '6701 was the best processor for this design based upon size, power, speed, and tolerance to single event latchup, signal event burnout, and total ionization dose. A review of the processor's performance and characteristics is provided to ensure the proper operation of '6701 in a TMR design.

The system employs a bit by bit voter that compares the three processors' results and outputs the majority of the bits. All data, address, and control signals are monitored to determine that the system is operating properly. This system significantly differs from previous TMR designs, because only address errors cause immediate interrupts. Data errors cause processor interrupts only when the errors accumulate to a critical level. An external host processor controls the processors' shared memory space.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Electronics, Computing and Software

KEYWORDS: Fault-tolerant Computing, Digital Signal Processors, Texas Instruments TMS320C6701, Commercial-off-the-Shelf Technology, Radiation, Triple Modular Redundant, Analog Devices ADSP-21060

MODELING JAMMING EFFECTS ON ROLLING AIRFRAME MISSILE

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Development of countermeasures against infrared and optical guided missiles is enhanced by an ability to quantify the effects of the countermeasure. Analysts must be capable of accurately determining the attitude of the missile throughout its flight. This thesis describes the use of microelectronic-miniature (MEM) technologies to measure the strap down rates experienced by a rolling airframe missile and the model required to effectively determine the missile's attitude during its flight. The Tokin America CG-16D rate sensors and the Honeywell, SSEC, HMC 1002 roll sensor were used in an inertial measurement unit (IMU). The size of the IMU is small and rugged enough to be installed in a small diameter missile. A SIMULINK model is presented that performs the tasks of demodulating the sensors, performing coordinate transformation, and providing animation of the missile attitude for analysis. The model was evaluated for its ability to accurately determine the attitude of the missile based on input from the IMU packages. Sensor data was obtained from testing performed on a CARCO table flight motion simulator, and compared to the ground truth data provided by the CARCO table. Previous research had proved that this model worked for slow-spinning missile (5 Hz in roll). This thesis research expands that research to a fast spinning missile (15 Hz in roll). Through testing, the model was capable of providing solutions within the 2 degrees RMS requirement.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Jamming Effects, Microelectronic-Miniature, MEM, Countermeasures, Infrared and Optical Guided Missiles

MODELING SECOND GENERATION FLIR SENSOR DETECTION RECOGNITION AND IDENTIFICATION RANGE WITH POLARIZATION FILTERING

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The influence of polarization filtering on maximum detection, recognition, and identification ranges of a generic second generation FLIR sensor is examined with a computational model. The scenario studied represents a second generation FLIR sensor mounted on an aircraft in level flight at 300m approaching a ship target. The target ship radiant signature is modeled with an advanced infrared signature prediction program, MuSES (Multi-Service Electro-Optic Signature). A weather file representative of Midlatitude Summer at sea conditions was utilized. Polarized sea background and path radiance calculations are performed with a polarized version of the SEARAD Radiance and Propagation Code. Results showed that there is an improvement in maximum range of the sensor for detection, recognition, and identification tasks when a horizontal filter is included, provided that the target does not have a negative degree of polarization. For detection task the improvements were found to be 33.48%, 35.65%, and 39.78% when the target has 0%, +2%, and +8% degree of polarization respectively. A better modeling of Apparent Temperature Difference (ATD) calculation is also developed. To improve the model use of polarized target model is recommended.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Thermal Imaging Systems, Minimum Resolved Temperature Difference, Polarization Filters

AIRBORNE EXPLOITATION OF AN IEEE 802.11B WIRELESS LOCAL AREA NETWORK

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Deployment of IEEE 802.11b wireless local area networks is increasing around the globe due to their cost compared to wired infrastructures, availability, versatility and recent performance gains in the areas of transmission speed. Coupled with its ease of implementation, IEEE 802.11b wireless local area networks provide a viable solution for convenient information access. Unfortunately, wireless LANs remain a new technology not fully understood by the organizations implementing them. IEEE 802.11b wireless local area networks are vulnerable to intrusion and exploitation due to its broadcast infrastructure. Adding a wireless network to an organization's internal LAN may open a potential backdoor into the existing wired network. This research investigates the feasibility of exploiting an IEEE 802.11b WLAN from an airborne platform for the purpose of gaining access into the backbone wired network. It explores the viability of exploiting the 802.11 standard through the Medium Access Control (MAC) Layer, looking at link analysis and the use of high-gain antennas and commercial-off-the-shelf (COTS) software to intercept and process these radio frequency signals. The research concludes with an evaluation of optimum flight profiles for intercepting and collecting IEEE 802.11b signals based on the performance in actual test flights.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: IEEE 802.11B Wireless LAN, Wireless LAN

APPLICATION OF THE ROBUST SYMMETRICAL NUMBER SYSTEM TO HIGH RESOLUTION DIRECTION FINDING INTERFEROMETRY

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This research has examined the benefits of using the Robust Symmetrical Number System (RSNS) to resolve ambiguities in phase sampling interferometry. A compact, high resolution direction finding antenna architecture based on the RSNS was developed to demonstrate experimentally the elimination of phase errors using a minimum amount of hardware. Previous work has determined that phase errors in the system will degrade the system performance. Several improvements were made to the original RSNS prototype antenna to provide enhanced performance. Adding isolators and supplementing the ground plane with copper tape (between the antenna elements), a reduction in the mutual coupling effects was accomplished. Mounting the microwave components on a brass plate also reduced errors contributed by vibrations and temperature. Tailor cutting all semi-rigid coaxial lines also helped reduce the number of connectors required to assemble the microwave circuit, also a source of phase errors. Matching the front-end amplifiers in each amplification stage rather than matching the characteristics of two cascaded amplifiers in each signal line has reduced relative phase errors between channels as well as matching the power outputs of the amplifiers. Two printed circuit boards were designed and built for the RSNS signal processor. The printed circuit boards provide a decrease in the electrical noise floor over the original design (assembled on breadboards). The new design has reduced the phase errors that were present in the first prototype system. The RSNS signal processing technique is able to provide a high-resolution phase sampled direction finding capability with an angular resolution of 1.9 degrees by using only three receiving elements (two interferometers).

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Robust Symmetrical Number Systems, Optimum Symmetrical Number Systems, Phase Sampling Interferometry, Direction Finding, Ambiguity Resolution